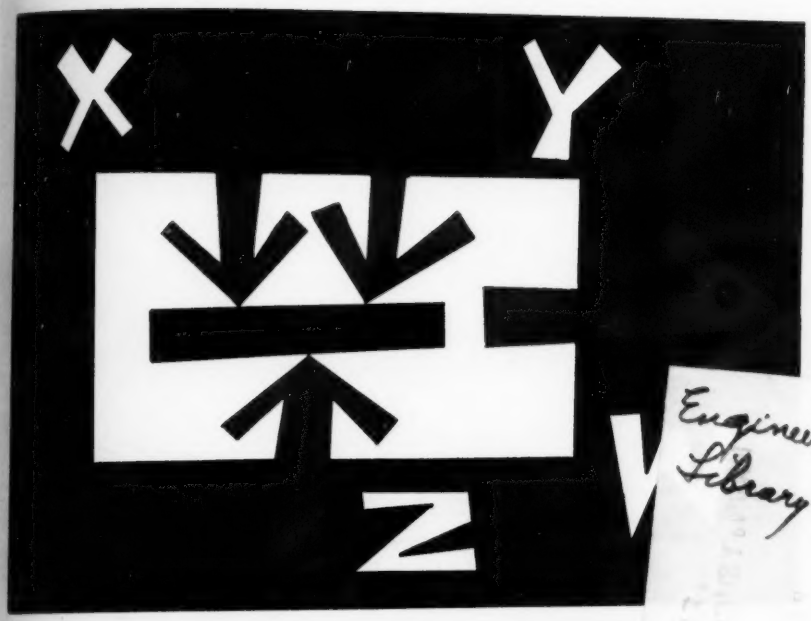
PAGE
54
10
86
5
34
27
22
25
87
92
71
32
8
91
2
51
39
COVER 4
47
33
94
43
69
64
66
7
50
24
88
4
93
97
93

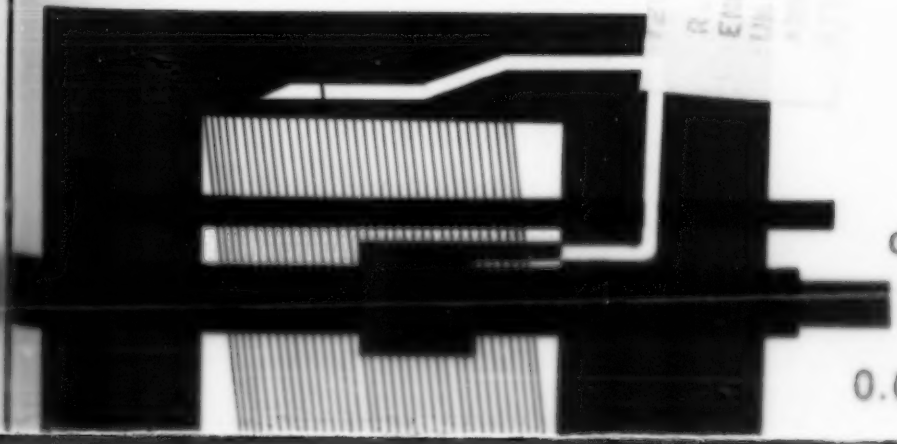
JUNE 1961

ELECTROMECHANICAL
components & systems DESIGN



solid state analog computing element replaces servomechanism

Engineering Library



one-inch pot with 0.01 linearity

TECHNIQUES IN THE APPLICATION OF SILICON POWER RECTIFIERS
Ratings; forward drop; reverse voltage ratings; thermal properties; protection techniques; overload protection; overvoltage protection; reliability.
FEBRUARY 1960 PAGE 30

ULTRASONIC DRILLING
Applied to ceramic parts. SEPT.-OCT. 1958 PAGE 80

VIBRATION-RESISTANT FASTENER

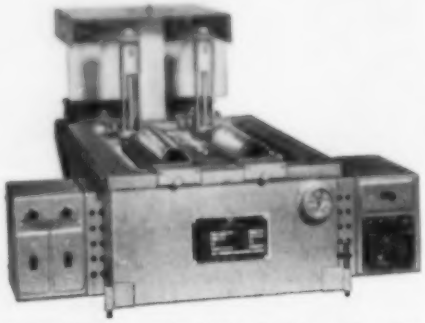
Methode Multiple Contact Connectors

DEE

Dual Wave SOLDERING MACHINE

For Improved Printed Circuit Soldering

Eliminates Hand and Conveyor-belt dipping.



Printed Circuit Soldering simplified through this new, proven "Dual Wave" method.
No "tear drop" or "tails"—less warpage. Long narrow boards as well as standards soldered with adequate joint penetration.

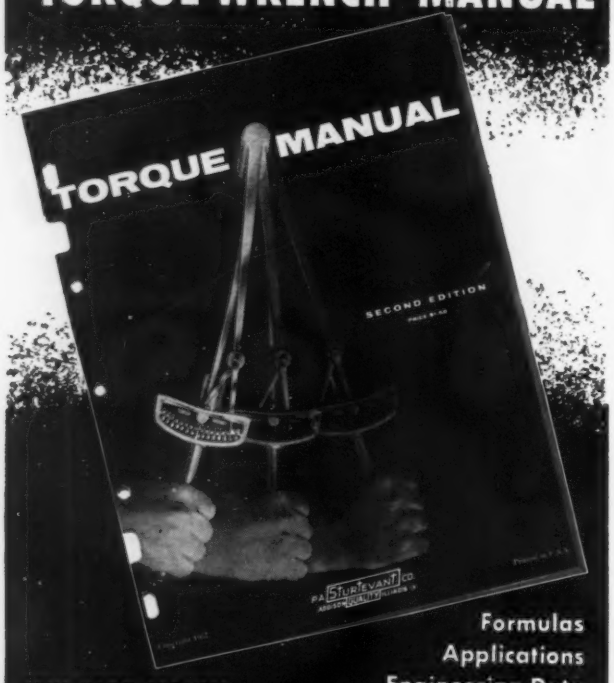
Write for details

DEE ELECTRIC COMPANY

1708 W. Belmont Ave., Dept. ED, Chicago 13, Ill.

CIRCLE NO. 73 ON INQUIRY CARD

"TORQUE WRENCH" MANUAL



SENT UPON REQUEST

Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Manufacturers of over 85% of the torque wrenches used in industry

CIRCLE NO. 72 ON INQUIRY CARD

E.M.D. INDEX

GYRO-ACCELEROMETER PACKAGE
Self-testing capabilities designed into equipment increase reliability. JUNE 1960 PAGE 58

HEAT TRANSFER TESTING
A c[illegible] ments [illegible] simple device. SEPTEMBER 1960 PAGE 52

HERMETIC SEALS
Fully serviceable mechanical seals for hermetic and hi-vacuum packages. OCTOBER 1960 PAGE 52

HIGH TEMPERATURE SOURCE
Small plasma generator produces 2500 to 12,000°F inexpensively. SEPTEMBER 1959 PAGE 37

INDUSTRIAL PRODUCT STYLING
Industrial design eases manufacturing problems and reduces production costs. JUNE 1960 PAGE 64

INFRA-RED INSTRUMENTATION
New detector gives fast response to cool body radiation. New refrigeration technique increases infrared sensitivity. Infrared radiation varies electrical conductivity of gold-germanium. JUNE 1959 PAGE 44

MICROMINIATURE CIRCUITRY
Thin film components for integrated circuits. DECEMBER 1960 PAGE 46

MILLIMICROSECOND PHOTOGRAPHY
Electrostatic image control, focussing and deflection. MAY 1959 PAGE 26

MOBILE VIBRATION TEST LAB
Shakers similar to radio speakers transmit high amplitude vibrations for aircraft structure tests. JULY 1958 PAGE 32

MOISTURE MONITOR
Cell electrolyzes moisture present in stripping gas. SEPTEMBER 1959 PAGE 38

MULTI-PURPOSE MAGNET WIRE
One film wire replaces six or more standard films. JULY 1960 PAGE 26

NEW MACHINE TOOL SYSTEM
Punched tape and transistorized computer convert blueprints into machined parts. APRIL 1958 PAGE 46

NYLON ADHESIVE
Quick-setting high strength bonds with only contact pressure. JULY 1960 PAGE 31

PACKAGE TECHNIQUES FOR SYSTEMS DESIGNS
Beacon transmitter for satellite and space vehicles. Subminiature rate gyro package. One million parts fit into one cubic foot by microminiature technique. Electronic "sardine sandwich" package. APRIL 1959 PAGE 40

PLASMA SPRAY
Coating technique vaporizes tungsten, converts it from gaseous to plasma state and sprays it on cold steel. NOVEMBER 1958 PAGE 40

POT WINDING AND SPACING CONTROL
Microphoto with 60-times magnification shows, extreme parallelism of wires and spacing produced winding equipment. DECEMBER 1958 PAGE 18

POTTING COMPUTER SUB-ASSEMBLIES
Protection against contamination, vibration and shock. SEPTEMBER 1960 PAGE 44

PRECISION BEARINGS
Two methods for measuring bearing preloads. JAN.-FEB. 1958 PAGE 50

PRINTED WIRING DESIGN
New photographic technique for designers. SEPT.-OCT. 1958 PAGE 74

PURE FLUID AMPLIFICATION
Pneumatic devices and systems with no moving parts. JUNE 1960 PAGE 60

RANDOM MOTION TEST TECHNIQUES
Methods for compensating test system resonances. JULY 1959 PAGE 24

RAPID FILM PROCESSOR
From test to film in twenty minutes. JAN.-FEB. 1958 PAGE 46

SCANNING PHOTOMETER
Density vs wavelength curves of spectrum displayed on oscilloscope. SEPTEMBER 1960 PAGE 42

TECHNIQUES IN THE APPLICATION OF SILICON POWER RECTIFIERS
Ratings; forward drop; reverse voltage ratings; thermal properties; protection techniques; overload protection; overvoltage protection; reliability.
FEBRUARY 1960 PAGE 30

ULTRASONIC DRILLING
Applied to ceramic parts. SEPT.-OCT. 1958 PAGE 80

VIBRATION-RESISTANT FASTENER
Locking insert helps reduce aircraft costs by 30%.
JULY 1960 PAGE 30

WIND TUNNEL DESIGN
"Crossed field acceleration". AUGUST 1960 PAGE 54

WIRE PACKAGING
Molded fiberglass harness cuts space, improves performance. AUGUST 1959 PAGE 24

WORKING MODELS
New machine kit for proving designs.
JAN.-FEB. 1958 PAGE 49

X-RAY METHODS
10 basic techniques help solve problems in the application of the x-ray. APRIL 1960 PAGE 48

RESEARCH

ANALOG-DIGITAL DIFFERENTIAL ANALYZER
Digital registers combined with analog elements provide greater precision than conventional analog computers.
NOVEMBER 1960 PAGE 45

CERAMIC FIBERS-TO-METAL
Bond withstands very high temperatures.
SEPTEMBER 1960 PAGE 53

COHERENT LIGHT SOURCE
Optical maser extends radio frequency band into optical range. SEPTEMBER 1960 PAGE 52

COMPREHENSIVE APPROACH TO RESEARCH EVALUATION
Judging past performance for the purpose of guiding future action. MARCH 1958 PAGE 56

DIFFUSED-BASE TRANSISTORS
Epitaxial films reduce switching time.
AUGUST 1960 PAGE 68

GERMANIUM DENDRITES
A "molecular electronics" material.
SEPTEMBER 1959 PAGE 41

GYROMAGNETIC RATIO OF PROTON
New measurement technique improves accuracy by factor of four. JANUARY 1959 PAGE 24

HI-TEMP RECORDER
New developments in recording oscillograph for aviation testing. APRIL 1958 PAGE 51

MAGNETO-THERMIONIC GENERATOR
External magnetic field permits greater design flexibility for high-power generation. NOVEMBER 1960 PAGE 42

MATRIC CALCULUS COMPUTER
One-to-one correspondence between network components and matric entries. SEPTEMBER 1959 PAGE 40

NEW ELECTRON SOURCE
Electron tubes may some day be transistorized.
SEPTEMBER 1959 PAGE 40

NEW THEORY FOR RUSTING OF IRON
Hydrogen ions from water vapor cause destructive reactions. DECEMBER 1960 PAGE 56

PARAMETRIC MODE TRANSISTOR
New development may simplify communication equipment and computers. NOVEMBER 1960 PAGE 47

RESEARCH EQUIPMENT
Superpressure made easy. APRIL 1958 PAGE 50

RUBIDIUM MAGNETOMETER
Here is a new method of indicating the strength of magnetic fields based on light absorption by rubidium vapor.
JULY 1958 PAGE 22

SPACE CABIN DESIGN JAN.-FEB. 1958 PAGE 43

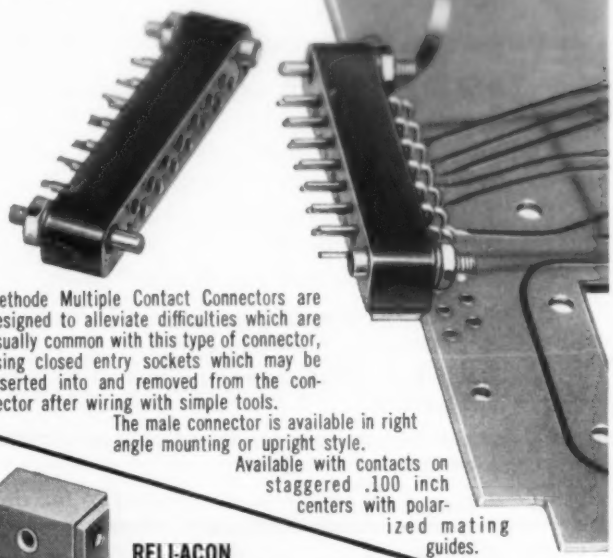
SPECTROSCOPY
VHF radio waves measure behavior of electrons.
APRIL 1958 PAGE 53

SUPERCONDUCTIVITY
Applications now possible in electronic circuits.
SEPT.-OCT. 1958 PAGE 98

Methode Multiple Contact Connectors

Designed for aircraft, radar, and missile applications. Especially suitable for use with printed circuit boards or, Flyo-Duct, Methode's flat multi-conductor cabling.

TWO PART PRINTED CIRCUIT CONNECTOR
Series MD-1100 and SD-1100.
Exceed requirements of MIL-C-8384 and NAS 713, 714, 715 where applicable.



Methode Multiple Contact Connectors are designed to alleviate difficulties which are usually common with this type of connector, using closed entry sockets which may be inserted into and removed from the connector after wiring with simple tools.
The male connector is available in right angle mounting or upright style.
Available with contacts on staggered .100 inch centers with polarized mating guides.

RELI-ACON FEED-THRU STYLE CONNECTOR Series FTD 1500
These connectors employ a tri-furcated contact which withstands extreme vibration. Presently available in 15 contacts on .100 inch centers for a nominal card opening of .062 inch. Moisture seal is available about the board or cable entrance.

Flexible multi-conductor wiring is available in standard sizes from stock or custom patterned to your specifications.

COMPLETE information and data are available on both of above connector types . . . write today.

Methode manufacturing corp.
7447 W. Wilson Ave
Chicago 31, Ill.

CIRCLE NO. 74 ON INQUIRY CARD

How To Assure
THE MAXIMUM
In High Response Clutch-Brake Systems

The clutch-brake unit you use must provide these basics:

1. minimum armature transfer distance between the brake and clutch housings.
2. clutch and brake friction surfaces held to a high degree of parallelism.
3. no backlash between armature and shaft.
4. clutch and brake friction facings burnished to give rated torque on installation.
5. closely held tolerances and finishes on all important surfaces.
6. minimum armature inertia without any sacrifice in mechanical strength.
7. magnetic circuit ability to respond to the field-forcing technique mentioned below.
8. positive armature release through absence of metal to metal contact and built in return action.

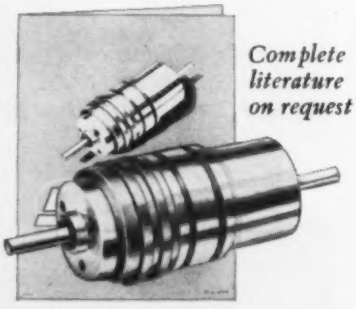
Because of the exclusive patented diaphragm, these features have been built into Simplatrol electric clutches and brakes.

The electric circuitry employed determines to a large extent the clutch reaction time. Reaction time is ordinarily reduced when a high momentary over-voltage is supplied (i.e., a voltage considerably in excess of the steady state rated voltage). Simplatrol can provide helpful suggestions on circuitry. Time required to bring load up to speed is a function of load inertia, r.p.m., and the torque of the clutch-brake.

Simplatrol's engineering organization will work with you to accomplish maximum speed, smoothness and quietness in your clutching and braking. Ask about applications of standard and custom designs in Simplatrol Electric Clutches and Brakes.

Investigate the total efficiency and economy of operation of the single complete unit, in torque ratings of 10 ounce inches to 470 pound feet, in sizes from 7/8" dia. to 12½" dia.

See for yourself the unique advantage of the flexible diaphragm action . . . the *only* moving part in a Simplatrol unit. Get the facts now on Simplatrol clutches and brakes.



Complete literature on request

Simplatrol products corp.
24-9 SALISBURY ST., WORCESTER, MASS.

Representation in Key Industrial Areas

371-0

CIRCLE NO. 75 ON INQUIRY CARD

ADVERTISERS' INDEX

ADVERTISERS	PAGE
Acromag, Inc.	54
Air Marine Motors, Inc.	10
Amperite Co., Inc.	86
Assembly Products, Inc.	5
Associated Spring Corp.	34
Automatic Electric Co.	27
Automatic Metal Products Corp.	22
Barden Corp., The	25
Barksdale Valves	87
Bodine Electric Co. *Div. of Vocaline*	92
Boehme, H. O., Inc.	71
Boesch Manufacturing Div. *Waltham Precision Instrument Co., Inc.,*	32
Bowmar Instrument Corp.	8
Bristol Motors	91
Burndy Corp.	2
Cannon Electric Co.	51
Carter Motor Co.	39
Clifton Precision Products Co., Inc.	Cover 4
Comar Electric Co.	47
Daystrom, Inc. *Transicoil Div.*	33
Dee Electric Co.	94
Devar Systems *Div. of General Kinetics*	43
Diehl Mfg. Co.	69
Electro Switch Corp.	64
Elgin Micronics *Division Of Elgin National Watch, Co.*	66
Faber-Castell, A. W., Pencil Co.	7
Fafnir Bearing Co., The	50
Fairchild Controls Corp.	24
Gear Specialties, Inc.	88
Globe Industries. Inc,	4
Graphic Systems	93
Gries Reproducer Corp.	97
Hamilton Manufacturing Co.	62
Handy & Harmon	58
Haydon, A. W., Co.	19
Haydon Switch, Inc.	72
Heinze Electric Co.	77
IMC Magnetics Corp. *Eastern Division*	53
IMC Magnetics Corp. *PSP Engineering Co.*	21
Inertia Switch, Inc.	75
Insco *Division of Barry Wright Corp.*	92
Instrument Development Laboratories, Inc.	30

ADVERTISERS' INDEX

ADVERTISERS	PAGE
Kearfott Division *General Precision, Inc.*	63, 65, 67
Keuffell & Esser Co.	71
Kollsman Motor Corp.	55
Laboratory for Electronics, Inc.	cover 3
Leecraft Manufacturing Co.	30
Librascope Division *General Precision, Inc.*	cover 2
Methode Manufacturing Corp.	95
Mosinee Paper Mills Co.	39
Motordyne, Inc. *Sub. of Air Marine Motors, Inc.*	10
National Semiconductor Corp.	13
North Atlantic Industries, Inc.	76
Pace Controls	98
Perfection Mica Co. *Magnetic Shield Div.*	26
Power Sources, Inc.	41
Powertron Ultrasonics Corp.	23
RF Products *Div. of Amphenol,Borg Electronics*	9
Rotiform Co., The	74
Rotron Manufacturing Co., Inc.	12
Simplatrol Products Corp.	96
Skinner Chuck Co., The *Electric Valve Div.*	17, 18
Southwest Products Co.	38
Spectrol Electronics Corp.	11
Sprague Electric Co. *Transistor Div.*	35
Sturtevant, P. A. Co.	94
Synchro-Start Products, Inc.	97
Technology Instrument Corp. of Acton	20
Theta Instrument Corp.	75
Thomson Industries, Inc.	23
Ucinite Co., The *Div. of United-Carr Fastener Corp.*	85
United Aircraft Corp. *Norden Div.*	1
U. S. Stoneware	6
Valcor Engineering Corp.	89
Wheeler Electronic Corp. *Div. of Sperry Rand Corp.*	70
Wright Machinery Co. *Div. of Sperry Rand Corp.*	42
Zero-Max Co., The	93

GRC tiny parts

Die Cast
ZINC ALLOY
Molded
PLASTICS

"SMALL ZINC ALLOY DIE CASTING"

Fact-filled booklet contains helpful designer's check list, exclusive GRC methods to help you create new products at substantial savings.

GRC's unique high speed, automated methods give you high quality, uniformly accurate small parts in die cast zinc alloy or molded Delrin, Nylon and other engineering thermoplastics . . . **at low cost.** GRC experience and exclusive techniques open the way to new design freedom, new production and assembly shortcuts. Write, wire, phone NOW for samples and detailed bulletins. Send prints for prompt quotation.

NO MINIMUM SIZE! Maximum sizes:
Zinc Alloy — 2" long, ½ oz.
Plastic — 1¼" long, .03 oz.

See us at the DESIGN SHOW Booth #1143; PLASTICS SHOW #1549

GRIES

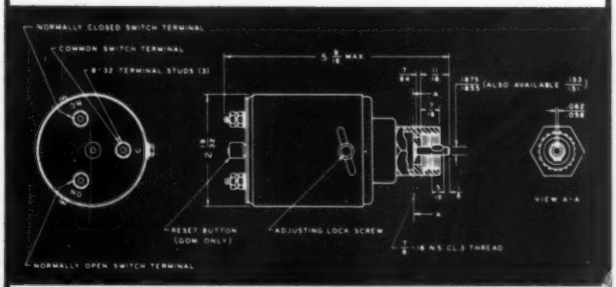
GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
119 Beechwood Avenue, New Rochelle, New York • NEw Rochelle 3-8600

CIRCLE NO. 67 ON INQUIRY CARD

MODEL GO

SPEED SENSITIVE SWITCHES

That can be furnished to trip at any given speed between 300 and 6000 R.P.M.
These switches have single pole, double throw, snap-acting contacts rated for 10 Amps at 115 V.A.C. A variety of dust covers and electrical connectors are available if exposed terminals are undesired.



SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE • SKOKIE, ILL.

CIRCLE NO. 66 ON INQUIRY CARD

SETTING THE PACE

by
Arthur L. Fitch
President
Pace
Controls
Corp.

ONE WAY TO MEET THE TREND TOWARD DIGITAL CONTROL

Pace Control's reason for being is based on a firm belief in the future of the automatic control industry. As we see it, our function is to provide means for accomplishing complex operations, efficiently and accurately, where manual or semi-manual skills are not adequate — or may not even be possible. We see it as our function, too, to provide a release from the tedium of repetitive operations. This is our governing philosophy and the reason behind this series of articles I've called "Setting The Pace".

Concurrent with our approach toward the control industry, we recognize that the demands of this era of industrial revolution for technical apparatus — and its control — are compounding themselves with each passing year.

Already, a decided trend toward the digital approach in the electronics industry is evidenced in the swing from devices that have been analog toward conversion to digital. This would include just about everything from computers to voltmeters. What's the explanation for this trend? It could be found quite possibly in the mounting demand for versatility, reliability and simplicity.

Now, if automatic control, particularly electronics, is to enjoy a boundless future, — and if the approach to electronic control devices is to lean more heavily on the digital approach, doesn't it seem logical to conclude that digital control, indeed, is a business with a future? We think so.

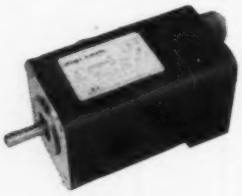
And it follows, with equal logic, that if the trend is toward digital electronics in the form of computers, programmers, read-in and read-out devices and a myriad of other electronic devices, it can be safely assumed that digital apparatus will do the work.

To a large extent, without DIGITORK (which we'll tell you about shortly), this just isn't possible. Even now, a completely digital control system will eventually terminate in digital to analog conversion to do work with analog devices.

We believe that the *completely* digital approach cannot end at the input. Rather, it must eventually be carried through to the output — and where necessary — again back to the input for checking reference.

DIGITORK — first and only motor of its kind.

Of the many hundreds of devices that must rely on digital type signals for their control — or would certainly be better if they did — DIGITORK can provide the answer. Perhaps the only answer. You can be sure *we're* sure when we make a statement like that! DIGITORK, by the way, is our trade name for family of products centered around a unique stepping motor principle. Here, we have a digital, torque-producing actuator responding in discrete increments of motion . . . one step for each pulse. The concept of application in its rudest element is . . . a desired motion — rotary, linear or



other — may be accurately controlled by the *number* of pulse signals furnished. The speed of the motion may be accurately controlled by the *rate* at which the signals are delivered to the control. Certainly, there's much more to tell about DIGITORK than this, but we're getting too close to the bottom of the page. We expect you'll want to learn the whole exciting story, so write in and we'll have it on its way to you by return mail.

In any case, with acceptance of the DIGITORK principle gaining momentum at an encouraging rate, we at Pace Controls foresee a most promising future. As we see it . . .

DIGITORK is truly...Setting The Pace!

PACE CONTROLS CORP.

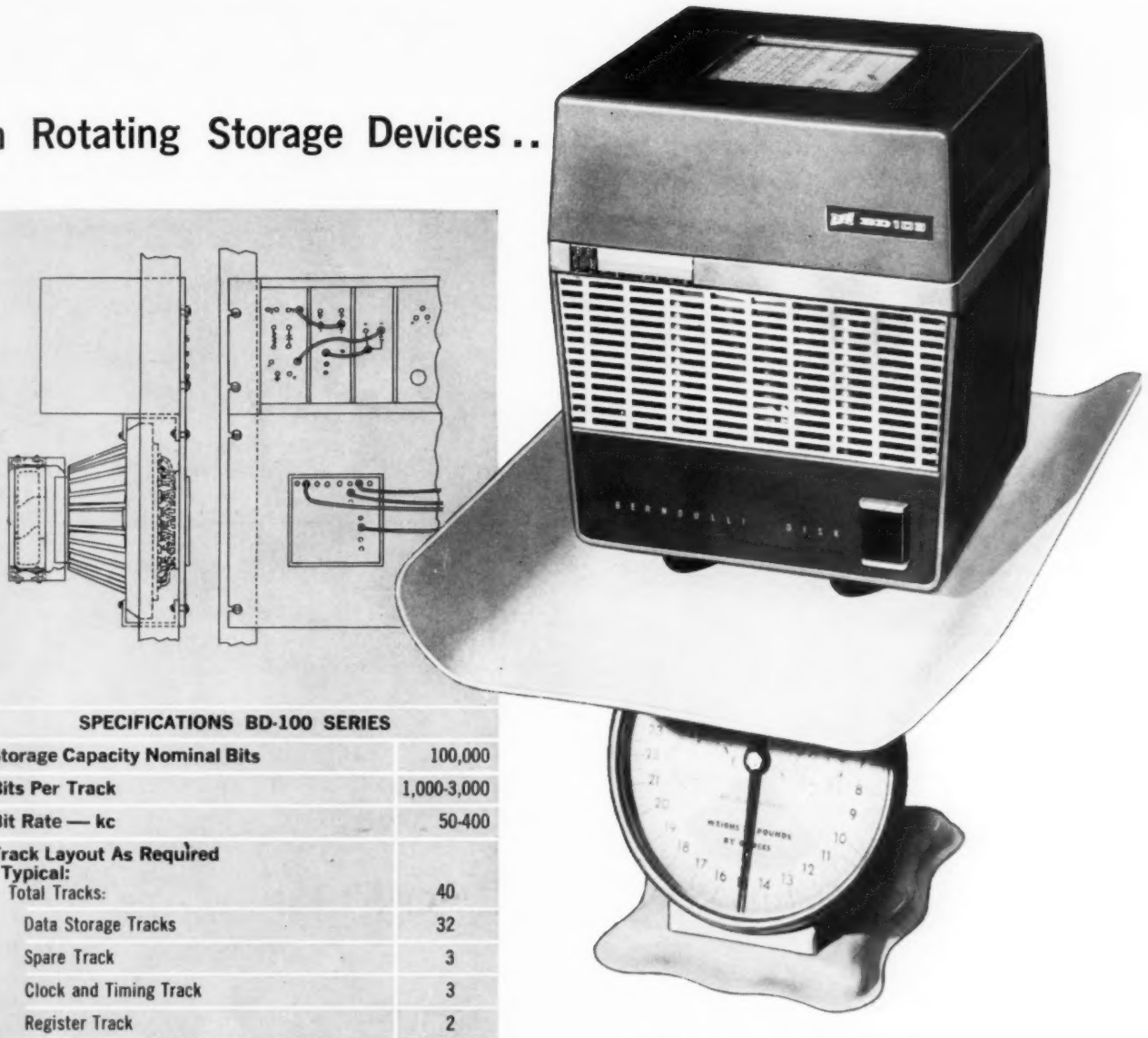
NEEDHAM HEIGHTS 94, MASSACHUSETTS
Hillcrest 4-8844

CIRCLE NO. 77 ON INQUIRY CARD

ADVERTISING PRODUCT INDEX

Product	Page
Accelerometers	51
Alloys, gold and silver	58
Amplifiers, servo	69
Bearings, precision	65
Bearings, self-aligning	38
Blowers	67, 77
Bushings, ball	73
Cloth, tracing	71
Clutches, adjustable slip	20
Commutators	30
Connectors, coaxial	22
Connectors, multiple contact	95
Controls, digital	98
Converters, analog-digital	1
Couplings. flexible	20
Dial assemblies	75
Differentials, synchronous	55
Disks, Bernouli	Cov. 3
Distributors	92
Drafting pencils	7
Electric valves	17, 18
Employment	Cov. 2, 61, 70
Encoders	1
Gear trains, servo	Cov. 4
Gears, helical	88
Gears, spiral	88
Inductors, toroidal	35
Inertia switches	75
Machine controls	5
Magnetic shields	26
Metals, precious	58
Motors, miniature	4
Motors, servo	42
Motors, stepper	19
Motors, synchronous	63
Paper, flame-resistant	39
Plastic parts	97
Potentiometers, non-linear	11
Power supplies	41
Precision parts	71
Pressure switches	87
Recorder, 3-pen	43
Regulators, ballast	86
Relays	9, 27, 47
Relays, delay	86
Resolvers	33
Scheduling boards	93
Servo components	8
Servo motors	42
Servo packages	Cov. 4
Shift registers, magnetic	35
Soldering machines	94
Solenoid valves	17, 18
Speed reducers	92
Speed drives, variable	93
Springs	34
Stamped parts	34
Summer courses, technical	68
Switches	9, 64, 79, 85
Switches, inertia	75
Switches, pressure	87
Switches, rotary	30, 64
Switches, speed-sensitive	97
Switches, stepper	19, 27
Synchros	33
3-pen recorder	43
Time inductors, elapsed	66
Timing devices	8
Torque wrenches	94
Transformers	70
Valves	17, 18
Valves, electric	17, 18
Valves, solenoid	89, 17, 18
Vibration isolators	85
Zinc alloy parts	97

In Rotating Storage Devices..



SPECIFICATIONS BD-100 SERIES	
Storage Capacity Nominal Bits	100,000
Bits Per Track	1,000-3,000
Bit Rate — kc	50-400
Track Layout As Required	
Typical:	
Total Tracks:	40
Data Storage Tracks	32
Spare Track	3
Clock and Timing Track	3
Register Track	2
Number of Registers	4
Register Length — Bits	32
Register Adjustment — Bits	±3
Disk Speed — RPM Induction or Synchronous Motors Available	1800-8000
Power Source — cps	60-400
Magnetic Heads (Compatible with solid state circuits)	
Typical: (For 200 kc Operation)	
Inductance (Per Leg. — C. T. Coil) — uh	55
Write Current (O/P Manchester) — ma	125
Read Out (Min. P/P Full Coil) — mv	20
Size — Inches (Less Electronics)	9 x 9 x 5
Weight — pounds	
Basic unit	15
With electronics	25

Wide variations from typical specifications can be made to meet customer's requirements.

...LFE Bernoulli Disks Deliver More Reliability Per Pound!

No other rotating storage device can match the LFE Bernoulli-Disk Memories for small size, light weight, low cost and high resistance to shock, vibration and temperature changes.

Simplicity is the key! A flexible magnetic disk, headplate and precision motor are the basic components. Positive separation between disk and headplate is maintained by centrifugal force and Bernoulli principles of fluid motion. The unit's low mass plus a cushion of air make damage to disk or read/write heads virtually impossible under even the most severe environmental conditions.

Available in standard customized models for bench or rack mounting, the BD-100 Series (illustrated) is compatible with all fixed station or mobile digital computers utilizing magnetic storage media. For complete information, please write Sales Manager, Data Storage Operations.

LFE
COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.
1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

CIRCLE NO. 79 ON INQUIRY CARD

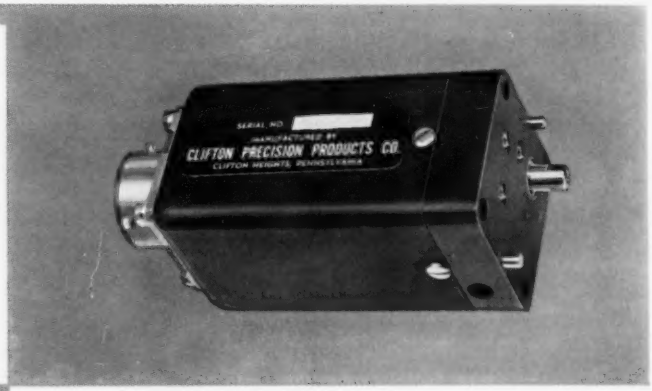
SERVO PACKAGE PROBLEMS ?

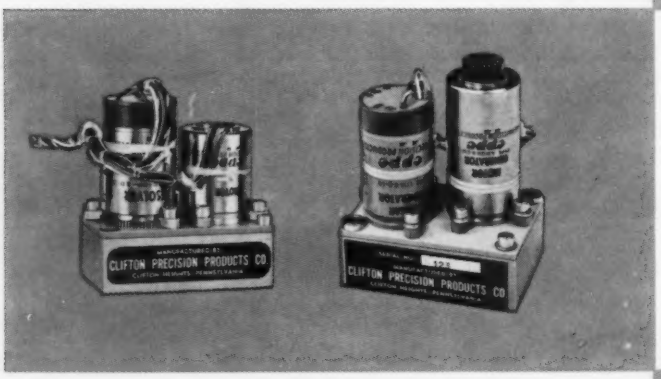
Here's how CPPC is advancing the state of the Servo Art through miniaturization including extensive weight reduction

A TRANSMITTER UNIT →

Within this miniaturized transmitter unit (1 17/64" square by 2½" long, less connector projection) is a size 8 synchro transmitter driven through a 100π:1 gear train. The input shaft features a detent action which accurately positions the transmitter in 13.7′ increments. There are 48 detents available and the transmitter EZ may be aligned with any detent.

A typical application of this unit is remote control of radar scanning equipment. **Weight: 3½ oz.**





← MINIATURE (2 ELEMENT) SERVO GEAR TRAINS

In the smaller assembly (1" wide by 1.812" long) any gear ratio up to 1000:1 can be supplied. In the other assembly (1.281" wide by 1.859" long) gear ratios up to 4000:1 are available. Choice of size 8 rotating components may be made for either design.

Depending on materials and components, **weight: 4 to 6 oz.**

MINIATURE (3 ELEMENT) SERVO GEAR TRAINS →

Two configurations are available to meet your mounting requirements (1.750" square or 1.188" wide by 2.500" long). In either design, gear ratios from motor to first rotating component of up to 1000:1 may be supplied, and up to 36:1 from the first rotating component to the second. Your choice of size 8 components for either design.

Depending on materials and components, **weight: 6 to 12 oz.**

Let CPPC Design Your Servo Package!

Perhaps the units shown are exactly what you have been looking for—or perhaps they are close to your needs. If not, the Systems Division of CPPC has the engineering knowledge and the production facilities to design and produce servo packages to your requirements—and all this supported by CPPC's precision rotating components of many varieties.

Why not give us the opportunity of reviewing your requirements for servo packages today.

cppc SYSTEMS DIVISION

For Further Information Telephone Or Write:

CLIFTON PRECISION PRODUCTS CO., INC.

Clifton Heights, Pennsylvania

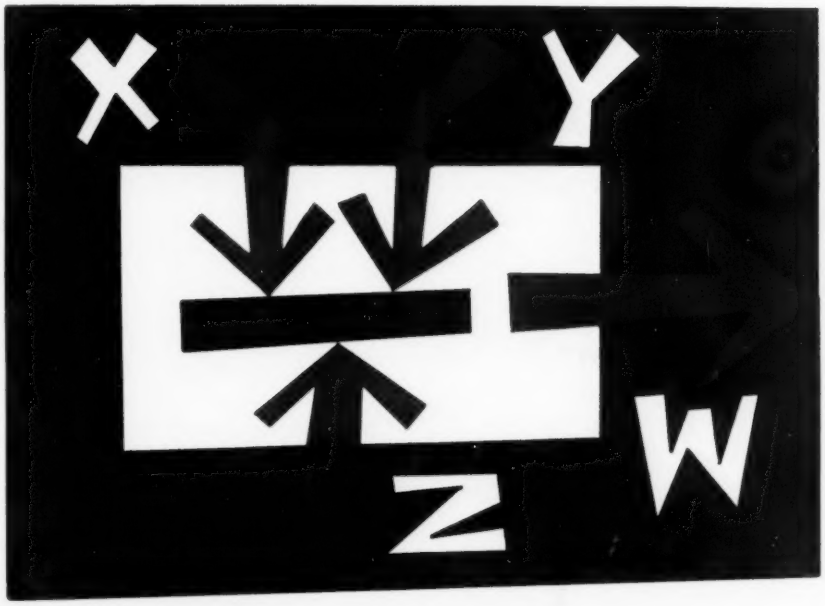
Sales Department: 5050 State Rd., Drexel Hill, Pennsylvania
MAdison 2-1000, TWX LNSDWN, PA. 1122(U)—or our Representatives

CIRCLE NO. 78 ON INQUIRY CARD

JUN -8 1961

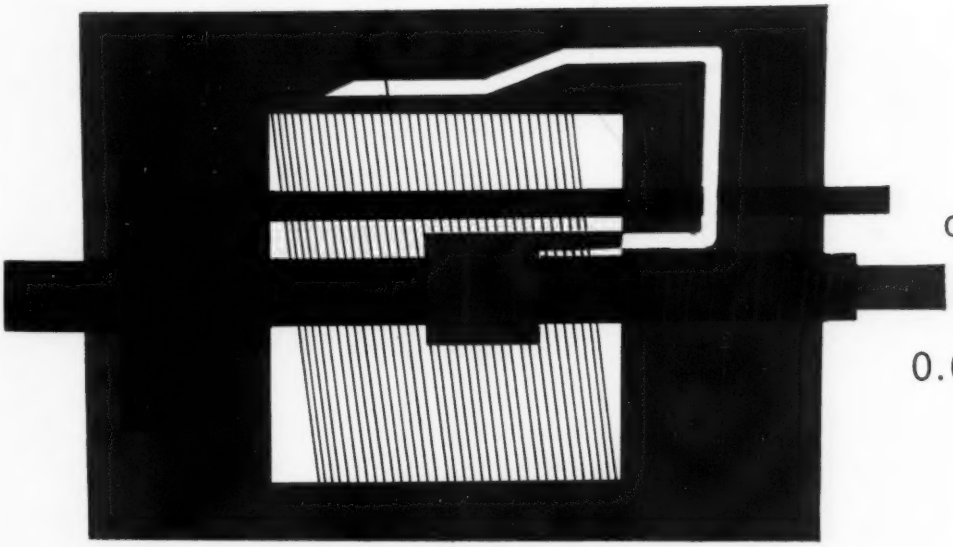
JUNE 1961

ELECTROMECHANICAL components & systems DESIGN



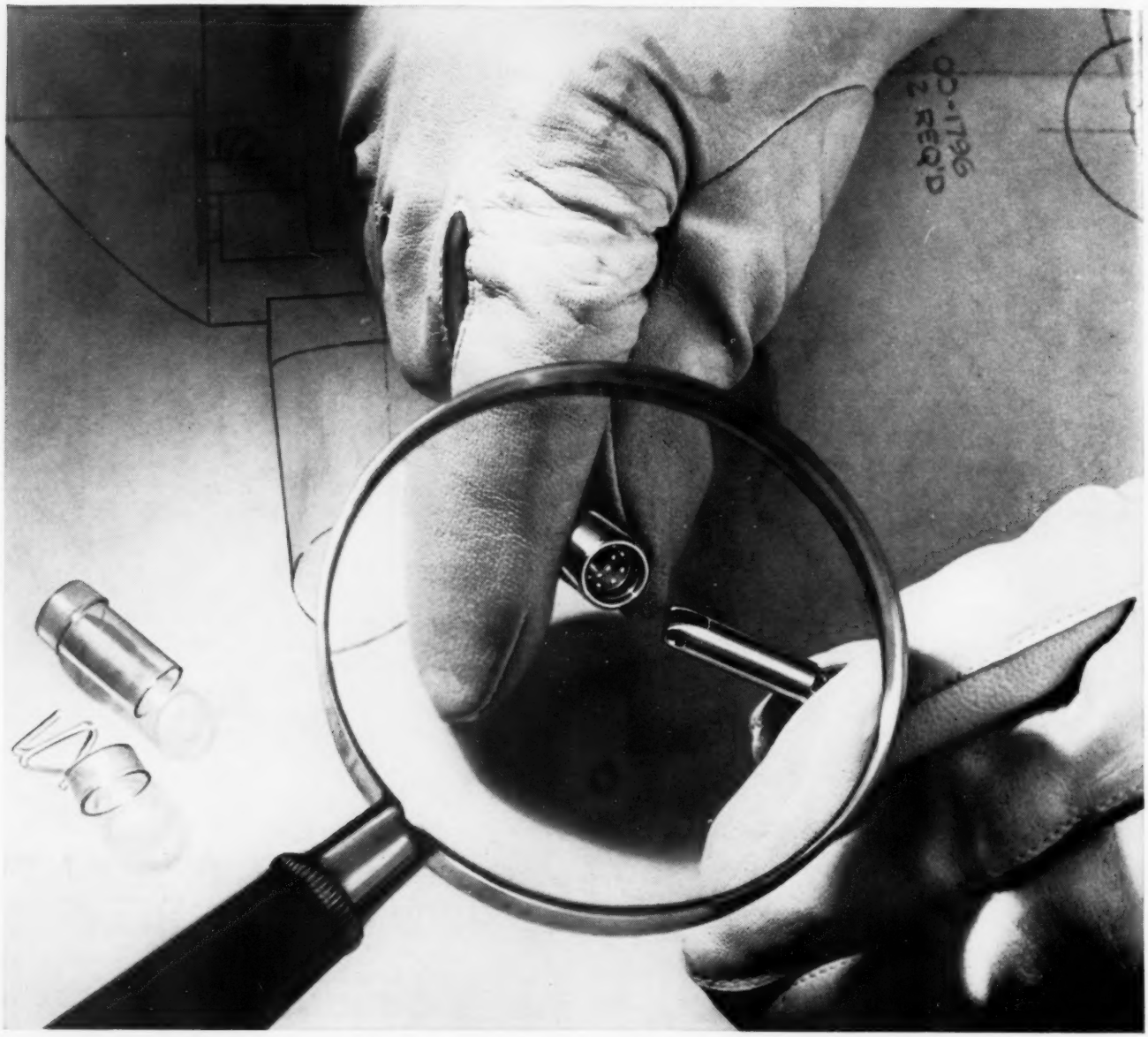
THE LIBRARY OF CONGRESS
SERIAL RECORD
JUN 8 1961
Body

solid state analog computing element replaces servomechanism



one-inch pot with 0.01 linearity

NEW DEPARTURES IN MINIATURE



HOW TO GIVE ON-THE-NOSE GUIDANCE TO MODERN "FISH"

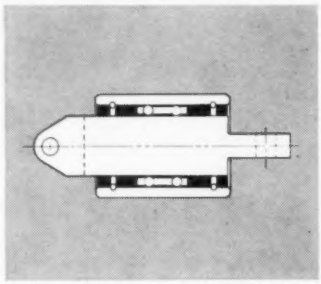
UNIQUE N/D LINEAR MOTION BEARING FREES GYRO CAGING ACTION

The bearing illustrated is an N/D linear motion precision instrument ball bearing. It was specially designed and built to help solve a critical problem in the guidance system of a high speed anti-submarine torpedo.

PROBLEM: Loss of accuracy in torpedo's guidance system due to hang-up of caging arm in gyro assembly.

SOLUTION: N/D Sales Engineer, in cooperation with manufacturer, found that *wear* of bushing on caging arm caused hang-up, delaying guidance activation. N/D Engineers set to work to design and build an instrument bearing that operates virtually friction-free. The result: Preservation of the guidance system's pin-point accuracy and reliability.

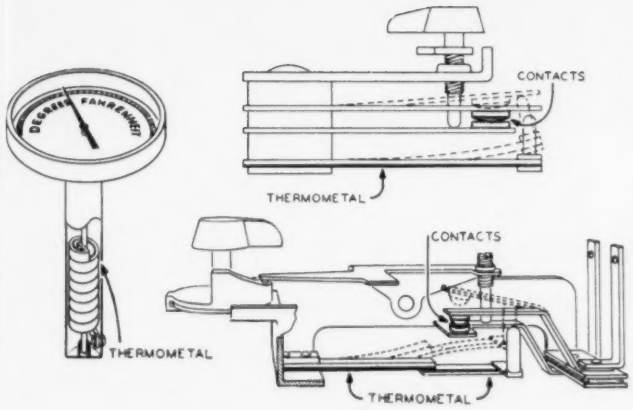
Should you require ball bearing design information, invite the local N/D Sales Engineer to participate in your early design discussions. He represents one of the industry's largest engineering staffs devoted exclusively to the design and development of miniature and instrument ball bearings. Or, write for new Miniature and Instrument Ball Bearing Catalog, Department L.S., New Departure, Division of General Motors Corporation, Bristol, Connecticut.



This special N/D linear motion instrument ball bearing increased guidance reliability of ASTOR torpedo weapon system developed by Westinghouse.

NEW DEPARTURE
MINIATURE AND INSTRUMENT BALL BEARINGS

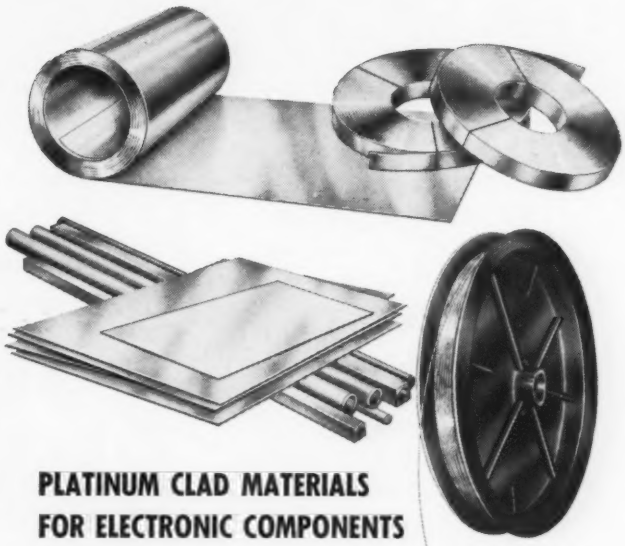
CIRCLE NO. 1 ON INQUIRY CARD



CONTROL TEMPERATURE, CURRENT AND VOLTAGE WITH THERMOMETAL®

Leading manufacturers rely on the dependable performance of Wilco Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

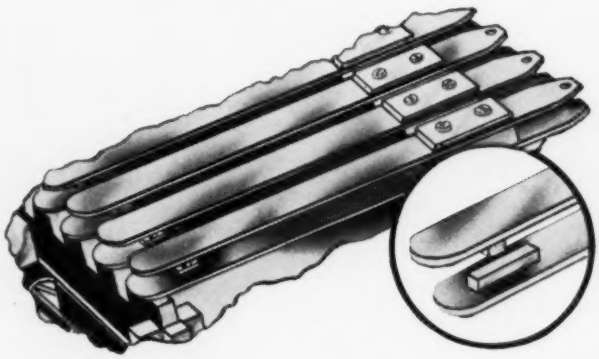
H. A. WILSON DIVISION
U.S. HIGHWAY 22 • UNION, N. J.



PLATINUM CLAD MATERIALS FOR ELECTRONIC COMPONENTS

Platinum clad wire, sheet and tubing provide all important desirable characteristics of the precious metals at minimum cost for electronic components. Pure or alloyed platinum is securely bonded to base metal with continuous pore-free platinum cladding guaranteed for ensuring reliable functional performance at elevated temperatures. • Gauge of platinum metal can be specified to requirements for economical parts and equipment fabrication. Write for literature.

BAKER PLATINUM DIVISION
113 ASTOR STREET • NEWARK, N. J.



ECONOTAPE CONTACTS ARE MOST EFFICIENT FOR ELECTRICAL RELAYS

High reliability welded contacts and contact assemblies available for your relays. Weld strength guaranteed. • Overall contact height held within ±.00025. Assemblies are available in gold, platinum, palladium, silver and their various alloys—both solid and laminated. Single contact usable for various contact ratings, for wet and dry circuitry—assemblies protected for shelf life and handling. Designs for attachment to header by welding or brazing. Complete electrical and mechanical design services available.

D. E. MAKEPEACE DIVISION
PINE & DUNHAM STREET • ATTLEBORO, MASS.

ENGELHARD
INDUSTRIES, INC.
EXECUTIVE OFFICES:
113 ASTOR STREET · NEWARK 2, NEW JERSEY

SALES OFFICES: CHICAGO • DALLAS • DETROIT • HOUSTON • LOS ANGELES • NEW YORK • ORLANDO • PROVIDENCE • SAN FRANCISCO • WASHINGTON, D. C.

* * *

Please send literature as indicated below, addressed to my attention:

☐ Thermometal ☐ Econotape

☐ Platinum Clad Materials

NAME.....

TITLE.....

FIRM.....

STREET.....

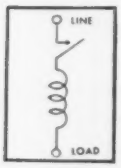
CITY.....ZONE.....STATE.....

FOR THERMOMETAL
CIRCLE NO. 2 ON INQUIRY CARD

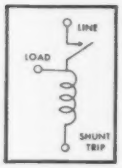
FOR ECONOTAPE CONTACTS
CIRCLE NO. 3 ON INQUIRY CARD

FOR PLATINUM CLAD MATERIALS
CIRCLE NO. 4 ON INQUIRY CARD

Heinemann's new VP breaker can work for you as two (or more) components in one. This matchbox-small breaker protects against overloads, also performs many specialized functions. (The internal circuits shown below will suggest its possible uses.) ■ The subminiature VP is magnetically actuated, requires no de-rating. You can have it with any integral or fractional rating from 0.050 to 15 amps (110V, 60 or 400 cycles AC, or 50V DC), and with a choice of several time-delay characteristics. Details on performance, construction and other points of engineering interest are in Bulletin VP; write for a copy. *Heinemann Electric Co.* *125 Brunswick Pike, Trenton 2, N. J.*

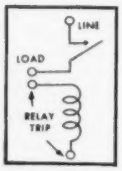


Series-Trip — Overcurrent sensing and circuit interruption take place in the protected circuit; breaker can double as a toggle switch.

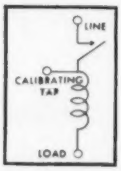


Shunt-Trip — Permits remote tripping through appropriate circuit-closing contacts in control or safety device. Shunt coil operates on line voltage.

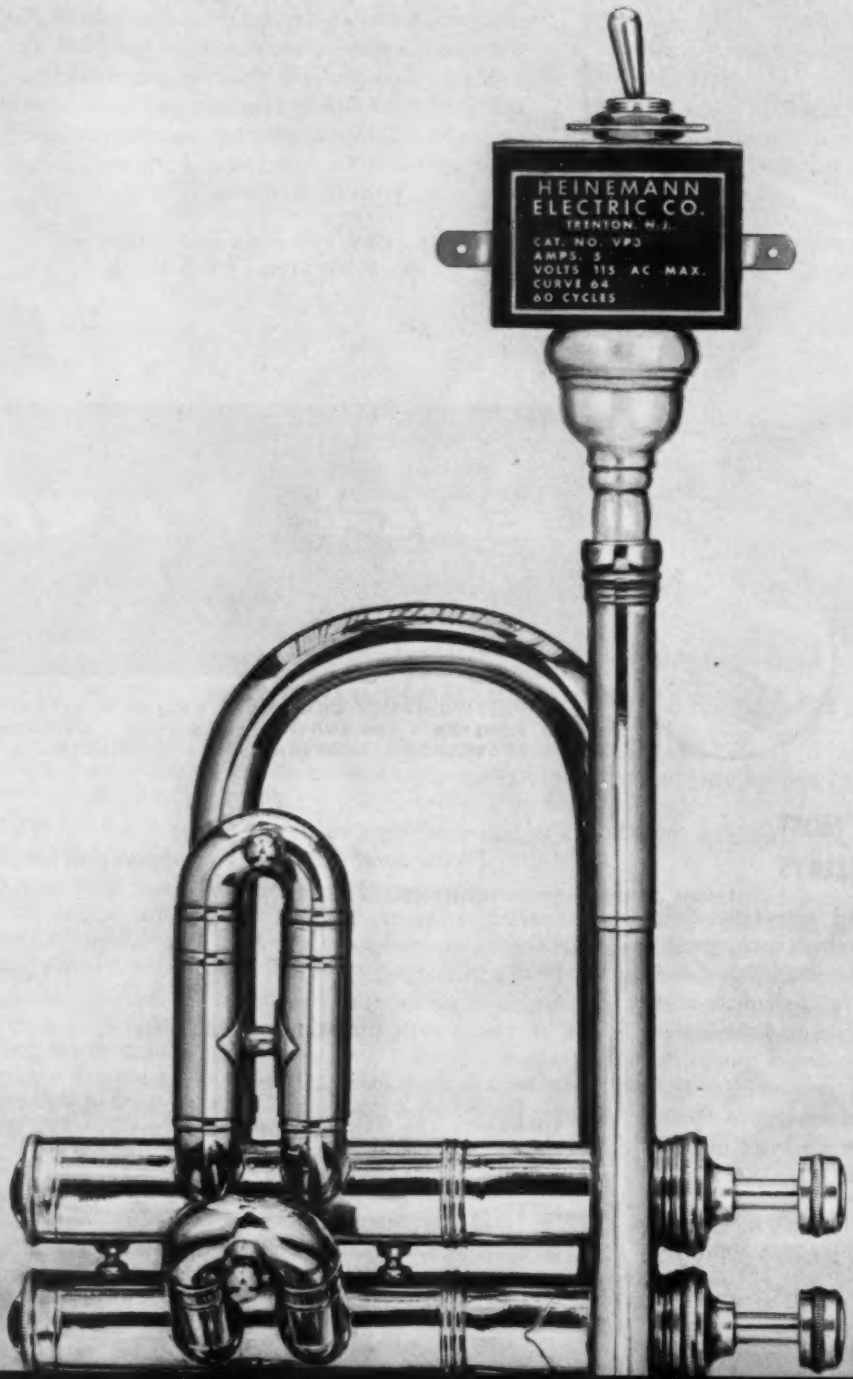
DOUBLES IN BRASS



Relay-Trip—Provides a separate control circuit through the coil terminals; any voltage or current can be used to trip the breaker remotely.



Calibrating-Tap—Permits control of two circuits, with tripping in response to overloads in main circuit only; may be shunted to raise current rating.



ELECTROMECHANICAL
components & systems DESIGN

The Sourcebook of Design Ideas in Applied Electromechanics

JUNE 1961 • VOL. 5 NO. 6

Contents

Components Design

14 ANALOG MULTIPLIER-DIVIDER
Plug-in solid state unit replaces instrument servo in analog computation

15 LINEAR MOTOR
Unlimited stroke without hydraulics or pneumatics

16 ONE-INCH POT WITH 0.01 LINEARITY
New wiper design removes many limitations on pot performance

19 ROTATING TRANSFORMERS
Frictionless current-transfer for rotating assemblies

Systems Design

24 GROUP REDUNDANT SERVOS
Failure detection and switching circuits for redundant systems

Testing

28 VIBRATION ISOLATION TABLE
Ball bearing supports isolate sensitive equipment from horizontal vibration and motion

29 SWEEPING OSCILLATOR
Accurate low frequency testing using RF techniques

Research

36 PNEUMATIC DIGITAL COMPUTER
Gas powered flip-flops with packaging density of 6000 per cubic inch provide electrical-pneumatic signal conversion

Components Digest

45 SEMICONDUCTOR DEVICES – COMPONENTS DIGEST 21, Part III
Thermistors, voltage-sensitive varistors, Zener diodes, point contact rectifiers

Departments

42 MATERIALS

65 NEW COMPONENTS FOR ELECTROMECHANICAL SYSTEMS

75 CONTRACTS

76 NEW CATALOGS FOR YOUR LITERATURE FILE

78 INDEX TO ADVERTISERS

80 PRODUCT INDEX

BPA Circulation for May over 29,000

© Copyright – 1961
Benwill Publishing Corp.
167 Corey Road
Brookline 46, Massachusetts

SUBSCRIPTION POLICY

ELECTROMECHANICAL DESIGN is circulated only to qualified research, development and design engineers in all branches of industry in the Continental United States, including government installations and universities. You can qualify for a complimentary subscription by sending us the following information on your company letterhead: your name and title, your company's products; the number of engineers in your department, the number of engineers in your company and a description of your development and design functions. Please indicate whether your major engineering function is electronic, mechanical or electro-mechanical. The letter containing this information must be signed by you. Address changes for current subscribers require a re-statement of above qualifications.

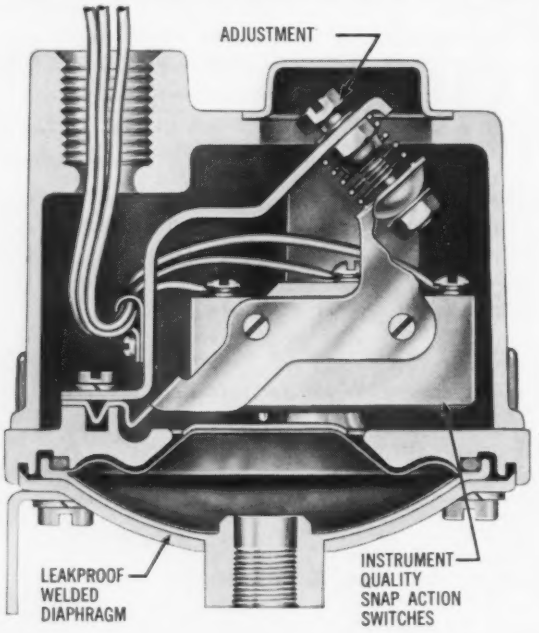
Home subscriptions to qualified subscribers are available at a service fee of $2.00 per year; subscription rate for non-qualified subscribers, $10.00 for one year only; library, group or company subscriptions, $10.00 for one year only. All foreign subscriptions, $20.00 for one year. Single copy $1.00 when available.

← CIRCLE NO. 5 ON INQUIRY CARD

BREAKTHROUGH IN PRESSURE SWITCH ACCURACY

at reduced prices

The high accuracy associated with instruments costing several hundred dollars is now obtainable with new Barksdale pressure switches at a retail cost of $19.00 to $30.00. Accuracy of ±0.5% is guaranteed and ±0.2% accuracy can be supplied when required. Substantial price reduction is accomplished by use of erector set design and a major investment in production tooling. A wide choice of "tailored to the job" features (see column at right) meets your specification requirements exactly.



THESE POINTS ARE IMPORTANT

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

New line of Barksdale pressure switches announced

Improved accuracy, reduced cost and higher proof pressures are advantages made possible by design innovations in the new Barksdale diaphragm pressure switches. Accuracy of ±0.5% as compared to the customary ±1.0% is guaranteed, and each unit is tested for repeat accuracy of set point and re-set point before shipment. Accuracies of ±0.2% are available on request.

Erector set design offers dual benefit

The basic unit of all Barksdale diaphragm pressure switches is a diaphragm surrounded by a heavy protective capsule to which components may be attached as required. Addition of a switch, switch bracket and adjusting bracket to the basic unit makes a stripped switch for use in a common cabinet with other electrical devices. (Original equipment manufacturers need not pay for a housing which is not needed.) Addition of a sealed housing to the stripped switch completes a weather- and vapor-tight switch unit. A standard housing with integral terminal block or an explosion proof housing with integral terminal block may be specified. Erector set construction allows a wide choice in specifications that approximates a custom made switch and permits use of cost-cutting mass production methods that are reflected in lower prices.

Proof pressures to 600 psi

In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof pressure to 10 psi. In higher ranges they will go up to 600 psi proof pressure at settings to 400 psi. This makes it possible to use inexpensive diaphragm pressure switches on installations that presently require higher priced bourdon tube switches.

Important additional advantages

Because the housings of Barksdale pressure switches are independent of the sensing and switching mechanisms changes in ambient temperature will not throw these switches out of adjustment.

The adjustment brackets are specially designed to protect switch terminals against shorting during adjustment.

Lead wires are held down by a tension clip. They cannot be pulled out accidently and thereby throw off the switch adjustment.

Mounting brackets may be oriented in any of four directions.

Tamper proof adjustment covers have servicing instructions on the inside to allow for painting of the units.

Standard pressure connection is ¼" n.p.t. female pipe fitting. One-half inch fittings suitable for mounting directly on ½" pipe can be supplied on request.

Standard housing has ½" nps conduit connections and a terminal block. The latter is accessible without removing the housing by lifting a cover plate.

Ask for new catalog and handbook

Complete details on Barksdale diaphragm, piston and bourdon tube pressure switches are included in a new catalog and handbook. This free book is a practical aid in planning the vital link between your electric and hydraulic circuits. It contains a glossary of terms, a schematic demonstration of operating characteristics, and a suggested step-by-step procedure for simplifying pressure switch selection. In addition, the book gives a complete run-down on all the detail features leading to the unit that answers your specific control problems. Send for your copy now, or ask your Barksdale representative.

CIRCLE NO. 6 ON INQUIRY CARD

ELECTROMECHANICAL
components & systems **DESIGN**

STAFF

Publisher	*H. G. Buchbinder*
Editor	*R. B. Brotherston*
Comp. Digest Editor	*Sidney A. Davis*
Associate Editor	*S. Henry Sacks*
Associate Editor	*Charlotte Kaizer*
Editorial Ass't.	*Elaine Bridgett*
Editorial Ass't.	*Berdine Freed*
Staff Columnists	*David Bandel* *Israel Katz* *Martin Kagan*
Contributing Editors	*H. D. Conway* *George King* *William Seifert* *Martin Glasberg* *Ronald Vickery* *William H. Barr*
Art Director	*James Flora*
Tech. Illustrator	*J. S. Brotherston*
Production Manager	*Keith Tower* *Lillian Greenberg* *Kathryn Metcalf*
Dir. of Circulation	*A. Allen Binder* *Gertrude Bandel* *Anita Weinberger* *Lillian Smith*
Mgr.-Reader Service	*Roger Le Cuyer* *Harry Kaizer* *Carol Walton*
General Administration	*Theodore Nichols* *Esther Shershow*
Ass't to Publisher	*Ruth Robinson*

OFFICES

NEW ENGLAND — *G. Palken*
167 Corey Road
Brookline 46, Mass.
BEacon 2-5470

NEW YORK — *M. Berns*
565 Fifth Ave.
New York 17, N.Y.
YUkon 6-3780

CHICAGO — *L. Woods*, *D. Sturgeon*, *A. Boz*
Macintyre-Simpson & Woods
75 East Wacker Drive
Chicago 1, Illinois
CEntral 6-1715

CLEVELAND — *L. Woods*, *A. Boz*
Macintyre-Simpson & Woods
1900 Euclid Ave.
Cleveland 15, Ohio
CHerry 1-1501

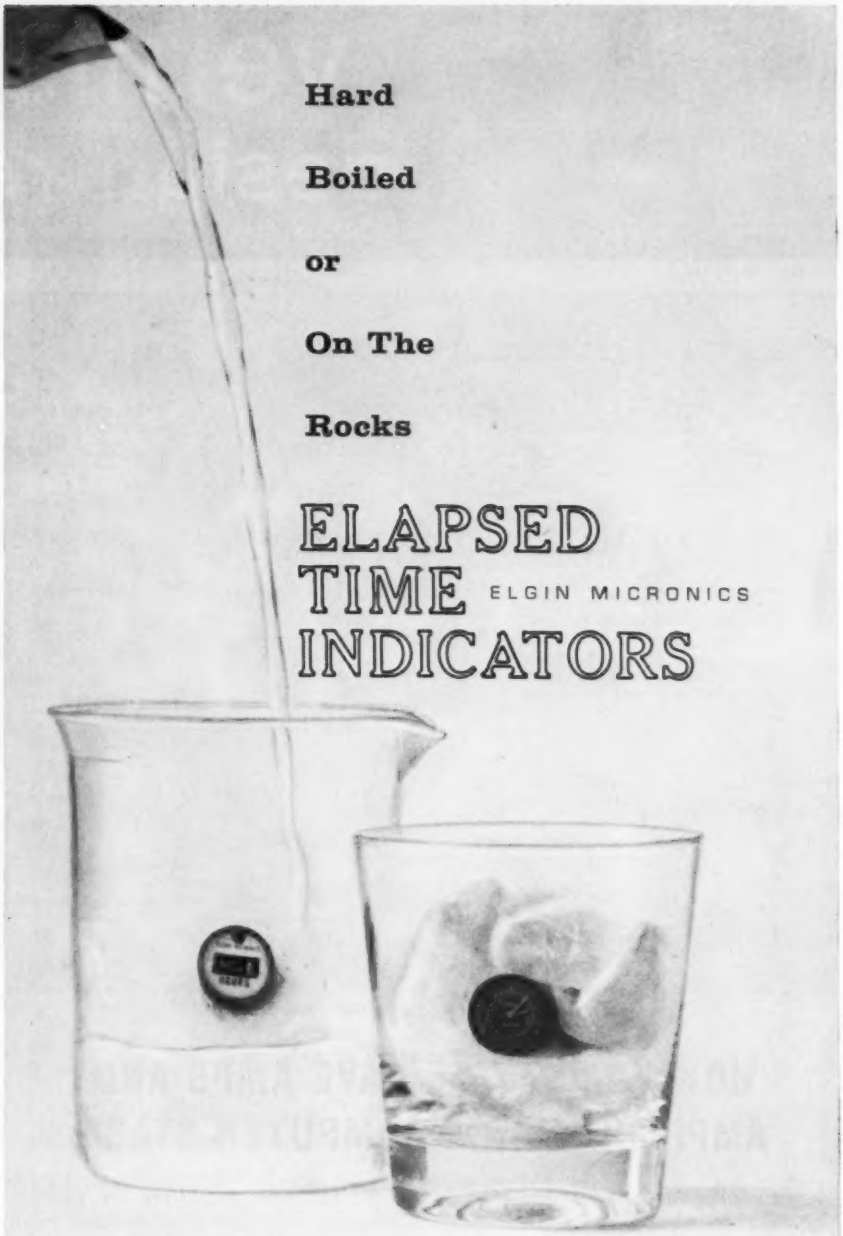
MIAMI — *J. B. Cashion*
904 Chamber of Commerce Bldg.
Miami 32, Florida
FRanklin 1-9941
MOhawk 1-7722

LOS ANGELES — *T. A. Schell*, *H. N. Schell*, *C. Meister*
2700 West Third Street
Los Angeles 57, California
DUnkirk 2-4889

SAN FRANCISCO — *C. W. Hoefer*
1664 Emerson Street
Palo Alto, California
DAvenport 4-2661

Published monthly by Benwill Publishing Corporation. Harold G. Buchbinder, President; Milton Berns, George Palken, Robert B. Brotherston, Vice Presidents, Executive, Editorial and Subscription Office 167 Corey Road, Brookline 46, Mass. Telephone BEacon 2-5470. Copyright 1961 by Benwill Publishing Corporation. Accepted as controlled circulation publication at Pittsfield, Massachusetts. Postmaster: send form 3579 to Benwill Publishing Corporation, 167 Corey Road, Brookline 46, Mass.

PRINTED AT BEN FRANKLIN PRESS, INC., 50 GREENWAY STREET, PITTSFIELD, MASS.



Hot or cold, anything between –65°F (cold enough to freeze even the driest martini) and 185°F is just comfortable for an Elgin Micronics ETI. If the heat is really on, they can be made to take 250° F, and they're hermetically sealed to operate in any atmosphere—or in no atmosphere at all! No wonder they're preferred by the men who design high-performance, high-flying equipment when they want true reliability data. Elgin Micronics Elapsed Time Indicators are small enough (only .680" in diameter) to fit anywhere and surpass MIL-M-26550A with ease. Write for bulletin ETI-1 today and check the detailed specs against your requirements.

ELGIN MICRONICS

DIVISION OF ELGIN NATIONAL WATCH COMPANY 386 Bluff City Blvd., Elgin, Illinois

Plants in Elgin and Rolling Meadows, Illinois and Chatsworth, California

Represented nationally by Airsupply-Aero Engineering Company, a division of The Garrett Corporation

CIRCLE NO. 7 ON INQUIRY CARD

vernistat®
design report

Information on Vernistat a.c. potentiometers for design engineers

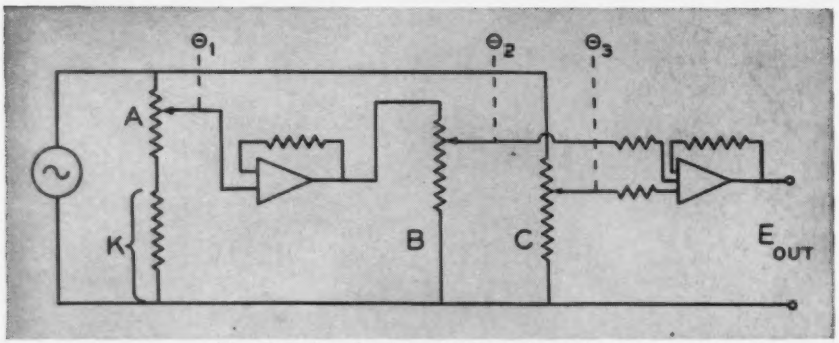


Fig. 1 Using Resistance Potentiometers.

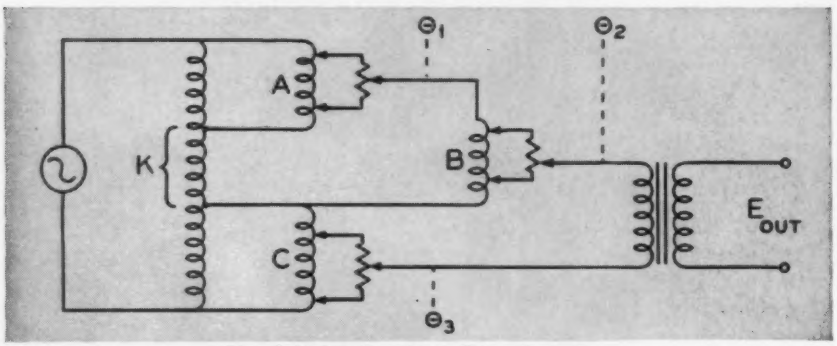


Fig. 2 Using Vernistat Potentiometers.

HOW VERNISTATS SAVE AMPS AND AMPLIFIERS IN A COMPUTER STAGE

Here's a whopping good example of an equation solved by two different circuits. It multiplies three variables (shaft angles) by three constants and throws in a couple of additions and multiplications for good measure:

$$E_o = (K + A\theta_1) \cdot (B\theta_2) + C\theta_3$$

At a glance you can see how the use of Vernistat precision a.c. potentiometers simplifies the circuit.

Due to the high output impedance of resistive pots, an isolation amplifier is required in the multiplication section of the circuit in Figure 1. For addition, summing resistors are used in conjunction with a feedback amplifier. The system is accurate enough, but it suffers on two counts: 1. the amplifiers chew up power and throw off heat; 2. use of the amplifiers reduces the circuit's reliability, since reliability is a function of the number of elements in a system.

No isolation amplifiers are needed, thanks to Vernistat's high ratio of input to output impedance. Addition is accomplished simply by using phase reversal in an input transformer. By eliminating amplifiers, the Vernistat gives you reductions in size, weight, power supply requirements and heat rise.

Don't overlook other advantages of the Vernistat. This remarkable, new circuit element provides high linearity, low phase shift and precise voltage division. It takes ten turns of the shaft to cycle through its voltage range, and the shaft may be turned **forward**, instead of backward, to its starting point.

If you're looking for high resolution with practically no background of phase-shift "noise" (quadrature), Vernistat a.c. potentiometers are for you! Make sure you get a full rundown on their construction, specifications and applications by writing to us.

If your business involves design of analog computers, servos, and other controls—then resolve to look into the Vernistat picture immediately! Our literature may help you soar to new levels of design thinking. Write now!

CIRCLE NO. 8 ON INQUIRY CARD

SIZE II VERNISTAT AC POTENTIOMETERS

These miniature, ten-turn components are approximately 1⅔ inches long, a little over an inch in diameter, and weigh only 2 ounces. The Series 4 operates at 400 c.p.s. at 20-40 volts maximum input. Input impedance is 2,500 to 30,000 ohms; output impedance, 40 to 200 ohms. Terminal conformity is ±0.05%. Series 4 Vernistats are 10-turn units and provide continuous rotation, since they have no stops.

Four Series 4 Vernistat models are available which cover the above ratings. They are useful as data transmitters, computer elements, driving elements for resolvers, servo follow-up components... for mathematical operations, voltage step-up, and phase reversal. Write for complete data on these high-precision components today!

vernistat division
PERKIN-ELMER CORPORATION
768 Main Avenue, Norwalk, Connecticut

THE

Blue Chip

OF THE MINIATURE

GYRO FIELD

Reeves proudly presents its latest achievement in precision gyro miniaturization . . . an extremely compact and rugged unit designed and produced to meet the most exacting requirements of service in advanced inertial reference packages and stable platforms.

Reeves 12IG Gyros are 1.25 inches in diameter, 2.5 inches in length overall, and weigh only 6 ounces. Trimmed drift rate is very low . . . 0.1° hr.— Mass unbalance, 1.0°/hr/g. Angular momentum, 30,000 c.g.s. units. Gyros can be supplied with or without case heaters. For more complete information, write for data file 406.

Reeves

12IG

THE ULTIMATE

IN MINIATURE

FLOATED

INTEGRATING GYROS

Qualified engineers who are seeking rewarding opportunities for their talents in this and related fields are invited to get in touch with us.

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America

Roosevelt Field, Garden City, New York

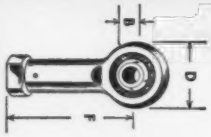
3RV61

CIRCLE NO. 9 ON INQUIRY CARD

Unibal®

THE ORIGINAL SPHERICAL BEARING ENGINEERED AND DEVELOPED BY HEIM

Unibal spherical bearings consist of a ball, with centralized bore, mounted, and universally movable in an outer member. They greatly simplify design problems requiring high-capacity, self-aligning bearings and rod ends, particularly in mechanical linkages.

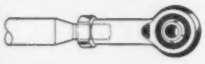


ROD ENDS

with internal (female) threading

An indication of the range of sizes

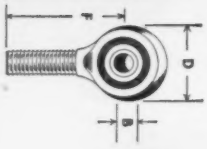
F—Length to center of ball .812 to 2.875
D—Outside diameter .469 to 1.750
B—Bore .125 to .750



Female rod ends are for linkages using rod stock.

ROD ENDS

with external (male) threading



An indication of the range of sizes

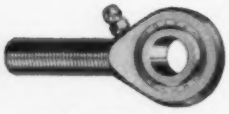
F—Length to center of ball .937 to 2.875
D—Outside diameter .469 to 1.750
B—Bore .125 to .750

Male rod ends are for linkages using tubular stock.

Materials used vary with specific requirements; balls are hardened steel, bearing inserts usually bronze, outer members can be of any suitable material such as carbon steel, aluminum, aircraft steel, etc.

Both male and female rod ends are available with lubricators.

Flush type lubricator

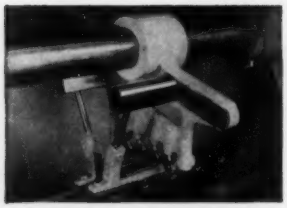


Standard lubricator

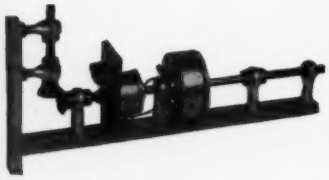
For self-aligning rod end bearings to withstand high loads at low speeds without lubrication, there are Unibal rod ends lined with "teflon".

An unthreaded shank series is also available for attaching by means other than threading. These are made with "B" dimensions from .190 to .250.

Unibal rod ends make excellent and inexpensive shaft supports and hangers.



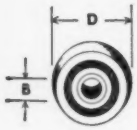
Suspension hangers for guide bars on knitting machine.



Shaft supports for clutch assembly shafts.

SPHERICAL BEARING, or cartridge unit

Designed to correct misalignment in every direction and to operate under high-static loads or reduced loads at low speeds.



An indication of the range of sizes

B—Bore .1250 to 1.8750
D—Outside diameter .4687 to 4.000

Three types of mounting for Unibal, showing angle of misalignment for each.

There are 2-piece Unibal bearings which can be had with conventional materials as well as with sintered iron balls, standard hardened steel balls, sintered iron or sintered bronze outer members, or almost any other suitable material.

Teflon provides long-wearing, low-friction, self-lubricating, high impact, vibration resistant properties when used as lining for Unibal bearings. For applications where speed ratings are not severe and minimum torque is essential.

Complete list of sizes, specifications, and load ratings is shown in Heim catalog and brochures. Please contact your nearest bearings distributor or write direct to manufacturer.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

CIRCLE NO. 10 ON INQUIRY CARD

TO THE ENGINEER

who needs the magic of mercury

If you're stymied by switching problems in data processing, automatic control or high-speed keying, then consider the unusual attributes of AE's Series V51 mercury-wetted contact relay.

This fleet switcher can be driven at speeds up to 100 operations per second, completely free from contact bounce. It requires no maintenance within its life of over a billion transfers. The contacts can switch dry circuits or handle loads up to 250 volt-amperes. Operate and release time is approximately 3 milliseconds.

Contact and armature assemblies of the V51 are hermetically sealed in a glass capsule with a high-pressure hydrogen atmosphere. Mercury wetting continuously renews the contacts, eliminates wear, erosion, welding and sticking. Operating sensitivity is 250 milliwatts, minimum.

AE engineers will be glad to aid in applying the V51 to your designs. Ask for Circular 1988 covering full specs on the V51. Write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

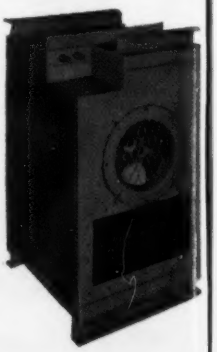
CIRCLE NO. 11 ON INQUIRY CARD

For

USAF MINUTEMAN:

a never-failing stream of chilled water for 3 years.

Assignment: For Boeing Airplane Company — design and produce a highly reliable water chiller for constant temperature control of Minuteman's guidance and control section. *Achievement:* A water chiller designed and produced for an MTBF of 232,558 hrs.; failure rate .430 x 10^{-5}. *Engineering Design Features:* *1.* Elimination of potential breakdown due to electrical contacts by utilizing a "solid state" activated modulating hot gas by-pass valve. System operates continuously, decreasing failure rate inherent in start-stop operation. *2.* Elimination of many moving parts. Example: Capillary tube replaces expansion valve. *3.* Hermetic refrigeration system, elimination of rotating seal. Immediately operational, even after prolonged storage. *4.* Temperature of supply water controlled to ±0.2 F. (Exceeded specification requirement of ±1.0 F.) *5.* "Flooded chiller" assures minimum capacity variance in ambient range of 50 F to 110 F. *6.* Adjustable temperature range of supply water from 36 F to 46 F. *7.* Withstands acoustical blast of 140 decibels. *8.* Meets the following specifications: (1) Salt spray — MIL-E-4970; (2) Shock and vibration (while operating)—±7.5 G, .4″double amplitude, Range 5 to 12 cps.; (3) Radio interference — (STL) GM07-59-2617A. *9.* Maintenance requirements extremely low due to features 1 through 4. *10.* Reduction of bulk through elimination of moving parts and simplification of design. Unit measures 17.75″x20.75″ x 33.85″h. Highly transportable and highly adaptable to various installations where available space is critical factor. *11.* Ellis and Watts performed all tests and supplied detailed reliability analysis report with water chiller units.



ELLIS AND WATTS PRODUCTS, INC.

Creative Engineering in Temperature and Humidity Control
• Air Conditioners • Liquid Coolers
• Dehumidifiers • Console Coolers
P.O. Box 33D, Cincinnati 36, Ohio

Norden minimizes magnetic encoder size

BuOrd SIZE 18 **GRAY-CODE MAGNETIC ENCODER**
SMALLEST AVAILABLE

KETAY DEPARTMENT of Norden offers this new encoder for applications where the combination of exceptionally long wear and high speed operation in a smaller package are vital. Strengthen your system or product design with this new high standard of performance factors:

- **Smaller size.** 1.750" diameter achieved by advanced techniques of ferrite disc magnetization.
- **High-speed performance.** Offers accurate readout at speeds to 10,000 rpm.
- **Almost unlimited life . . .** since encoder is not subject to disc-to-brush contact and wear.
- **Very low-starting and running torque.**
- **Completely unambiguous output.**

TYPICAL SPECIFICATIONS

Total Count	2^8 Gray Code
Rev./Full Count	1
Moment of Inertia	21 gm-cm²
Output Voltage	3 volts PTP min.
Breakaway Torque	Less than .05 oz/in
Maximum Speed (continuous interrogate)	10,000 rpm
Slew Speed	10,000 rpm
Diameter	1.750"
Weight	Under 5 oz.
Temperature Range	−65° to +125° C.
Vibration and Shock	Conforms to MilE-5272A

Send for more information on this unit and

OTHER MAGNETIC ENCODERS NOW AVAILABLE from Ketay: Gray multi-turn size 18 with count capacities of 8, 15 and 22 digits; V-scan binary size 18 with capacities of 7, 13 and 19 digits; binary coded decimal with 8-4-2-1 or 4-2-2-1 code; pure binary or cyclic units with counts of 100, 1000, 10,000. Special disc patterns and count capacities can be produced to your requirements.

Advanced Ketay techniques are also facilitating the development of SIZE 11 Gray and V-scan encoders offering this same capacity.

Ketay also manufactures a complete line of precision synchros, servo motors, resolvers, motor tachometers, gyros, amplifiers and encoders in a wide range of sizes and specifications to meet your specific requirements. Components are available separately or in modular packages.

NORDEN

division of UNITED AIRCRAFT CORPORATION

COMMACK, LONG ISLAND, NEW YORK

CIRCLE NO. 13 ON INQUIRY CARD

← CIRCLE NO. 12 ON INQUIRY CARD

ENGINEERING NEWS-#4

BASIC PRECISION SWITCHES

CHECKED	ENGR.	CONTROL SWITCH DIVISION

Meet Thousands of Application Needs with these Five Basic Switch Types

STANDARD MODELS in a wide range of dimensional and characteristic designs—from the tiny, powerful sub-subminiature type to the large, general purpose type where size is not important. See each switch series for application suggestions and brief specifications.

VARIATIONS—hundreds available—designed and engineered to meet such specific requirements as:

U.L. listings
high temperatures
dry circuitry
extra long life
high electrical ratings
reset for 2-way limit
high in-rush
AN and MS specifications
special terminals

ACTUATORS—toggle, push-button, leaf, roller leaf, lever, roller lever, etc., available.

Choose the Switch Series that meets your basic application needs. Then tell us the specific characteristics you want. Chances are, we have a standard ready for your use. We are fully equipped to make the switch you need in any quantity.

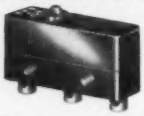
perfect for super-sensitive uses...

T SERIES

SUB-SUBMINIATURE, SPDT, 1/2" x 1/4" x 3/32"
high current capacity in tiny case.
excellent shock and vibration resistance.
solder terminals, others on request.
25,000 ops. min per MIL-S-6743.
7.5 amps @ 125/250 VAC, 60 cycles Ind. & Res.

ideal for compact, precision control uses...

E4 SERIES



SUBMINIATURE, SPDT, 25/32" x 1/4" x 23/64"
low movement differential and operating force permit precision control in critical applications.
solder; single, double and long double turret terminals.
150,000 ops. @ 125/250 VAC, 2.5 amps.

for rugged, low-cost, easy wiring uses...

F SERIES

MINIATURE, SPDT, 1 13/32" x 13/32" x 5/8"
rugged, low-cost design.
convenient terminals simplify wiring.
solder, screw and spade terminals.
150,000 ops. 10 amps @ 125/250 VAC, 28 VDC Res.

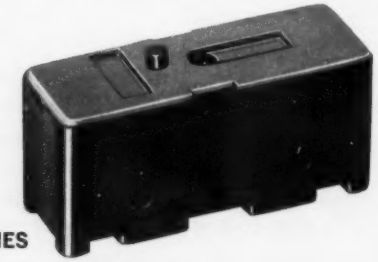
good for power circuits, precision control uses...

S SERIES

2-CIRCUIT, SPDT double break, 1 1/4" x 1/2" x 1/2"
combines high capacity, moderate size, long life and precision control.
tested to 10,000,000 operations.
end and side solder, screw and spade terminals.
750,000 ops. @ 125 VAC, 10 amps., U.L. rated.

for general purpose, high in-rush and repeatability uses...

S2B SERIES



SPDT, 1 15/16" x 11/16" x 57/64"
tough, durable, compact.
handles high in-rush loads easily.
repeats to 10,000,000 cycles min.
screw terminals.
20 amps, 125/250/480 VAC, U.L. rated.
1/2 amp, 125 VDC; 1/4 amp, 250 VDC.

For more details on these basic precision switch types write for catalog No. 110.

CONTROLS COMPANY OF AMERICA
CONTROL SWITCH DIVISION
1416 Delmar Drive, Folcroft, Pennsylvania • Telephone: LUdlow 3-2100 • TWX SHRN-H-502

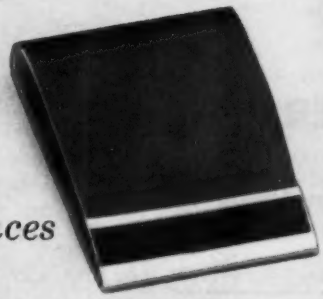
Manufacturers of a full line of switches, controls and indicators for all military and commercial applications.
All standard units stocked for immediate delivery by leading electronic parts Distributors.

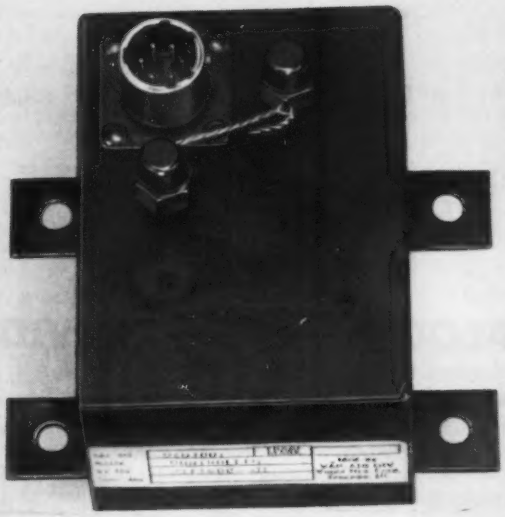
CIRCLE NO. 14 ON INQUIRY CARD

All switches shown actual size.

VĀP-AIR SINGLE-CHANNEL ON-OFF TYPE MAGNETIC AMPLIFIER CONTROL

accurate, reliable, yet smaller than a pack of cigarettes! weighs only 12 ounces





This Vāp-Air On-Off Type Magnetic Amplifier Controller is the smallest and lightest unit of its type on the market. It is fully encapsulated, gives accurate, reliable performance in conditions of severe shock and vibration. It has many applications . . . for overheat warning, heater control, windshield temperature control, etc.

BRIEF SPECIFICATIONS

Power Requirements	4 watts max. @ 115 V. 400 cps
Ambient Temperature	–65° F to 200° F
Load	2 amps resistive @ 28 VDC or 115 VAC
Weight	0.75 lbs.
Dimensions	2.3" x 2.23" x 3.1"

MULTIPLE CHANNEL ON-OFF TYPES, TOO

These small, lightweight units afford a variety of two, three, and four-channel on-off magnetic amplifier controls for overheat warning, heat controls, etc. In all of them, the pilot relay has been eliminated, and MS type contactors are operated direct, increasing the reliability of the complete system.

Units feature extreme accuracy and repeatability of operation. Built-in fail-safe features. Meet MIL-E-5272A.

Ambient Temperatures	–65° to 160° F
Weight (4-channel unit)	2.4 lbs.
Dimensions (4-channel unit)	3.25" x 4.75" x 3.1"

VĀP-AIR . . . COMPLETE CONTROL CAPABILITIES

Vāp-Air has specialized in aircraft temperature controls for nearly 20 years. Entire systems and a complete line of sensors, electronic controls and precise voltage regulators, electropneumatic and electromechanical valves, advanced in-line valves and regulators, electric power controllers and heat exchange equipment—for aircraft, missiles, and ground support devices.

VĀP-AIR DIVISION · VAPOR HEATING CORPORATION
80 East Jackson Boulevard, Chicago 4, Illinois

NEW YORK · ST. PAUL · DENVER · WASHINGTON · PHILADELPHIA · SEATTLE
SAN FRANCISCO · HOUSTON · RICHMOND · LOS ANGELES · ST. LOUIS

VĀP-AIR Division, Vapor Heating Corporation
80 East Jackson Boulevard, Chicago 4, Dept. 62-F

Please send further information on your On-Off Type Magnetic Amplifier Controls.

Name_____

Firm_____

Address_____

City, Zone, State_____

CIRCLE NO. 15 ON INQUIRY CARD

Fig 1 Solid state multiplier-divider by Elasco

ANALOG MULTIPLIER-DIVIDER

Plug-in Solid State Unit Replaces Instrument Servo in Analog Computation

Taking advantage of unusual electrical properties in a unique material, Elasco of Boston, Mass. has developed an inexpensive solid-state computing device that performs the operation

$$D = \frac{A \times B}{C}$$

with much better than 0.1% accuracy and at a fraction of the cost of equipment with equivalent performance. Parameters A and C are completely isolated, and may differ in form, from parameters B and D. This isolation allows mixing of a-c and d-c signals in the computation with no loss of accuracy.

The device is essentially equivalent to a servomechanism of the configuration of Fig 2. It carries out the functions of the servomechanism, with a high order of accuracy, and with no moving parts. Because of its exceptional ruggedness and compactness it is adaptable to military applications where environmental conditions are very severe. The unit, shown schematically in Fig 3 comprises a basic computation element, and a power amplifier. The computation element is an array of solid state resistors set up in bridge circuits. As viewed externally, these resistors act as pure ohmic elements capable of carrying ac or dc currents. A dc control signal is applied so as to modify the values of the resistors to unbalance the bridges of which they are a part. These two separate and isolated resistor bridges correspond to the potentiometers P^1 and P^2 in the functionally equivalent servomechanism of Fig 2. The corresponding semiconductor elements are precisely matched for all operating conditions including temperature change. Accuracy in effect depends on the quality of this matching, provided that loop gain is high enough to minimize balancing errors.

The power amplifier is not a precision device. It is required to have high gain, and a drift-free dc output,

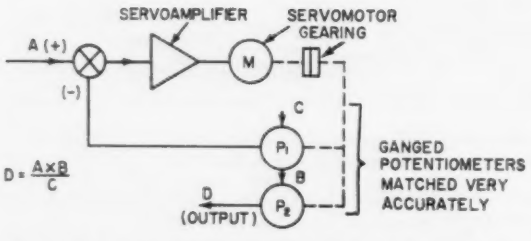


Fig 2 Schematic diagram of feedback servomechanism equivalent to Elasco solid-state multiplier-divider. The ganged potentiometers are not in themselves required to be highly accurate, but only accurately matched. Since the signals associated with P_1 and P_2 are isolated, they may be different in nature. Signals B and D may be ac signals, and A and C may be dc, or vice versa, etc. This isolation is a particularly convenient feature for many applications.

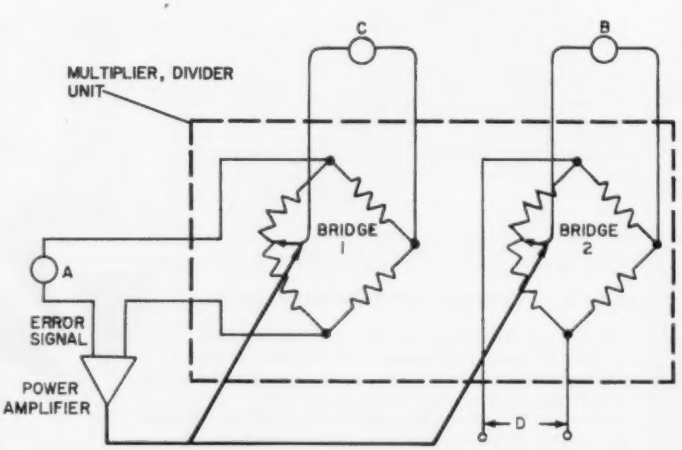


Fig 3 This solid state multiplier-divider is equivalent to the servomechanism of Fig 2. The complete isolation of the separate bridges greatly simplifies the application of this unit.

but within wide limits its gain factor, analogous to the servo-amplifier of Fig 2, is not important. The dc output of this amplifier provides the control power that changes the ohmic values of the bridge resistors. The amplifier is available as a vacuum tube or solid state device. A high output impedance is helpful in extending the bandwidth of the multiplier, since changing of the bridge resistors is primarily a function of control current.

Drift in the amplifier obviously appears as a false input signal, and must therefore be held to a limit consistent with required accuracy. If a 10 volt signal voltage is applied (voltage A, Fig 3) the multiplier must respond by developing nearly 10 volts as a balancing voltage. Obviously, a drift voltage in the amplifier equivalent to 0.020 volts at its input introduces an immediate error of 0.020/10, or 0.2%.

In many multiplication applications, frequency of the signals will not be dc, but rather 60 cps, 400 cps, or some other low audio frequency carrier. In such instances the drift of the amplifier can be drastically reduced by amplifying the ac null signal to its full level before converting to dc. For best accuracy on dc, a chopper (probably of the solid state type) can be introduced in the null channel.

Bandwidth of the system is easily extended by suitable amplifier design, and by insertion of equalizer networks in the null loop, to meet the requirements of applications requiring rapidly changing inputs. These networks are analogous to the lead networks commonly used to stabilize servomechanisms of the type shown in Fig 2.

PERFORMANCE

Performance of the Elasco multiplier-divider is essentially equivalent to that of the servomechnism of Fig 2. Accuracies to better than 0.1% have been achieved, together with bandwidths that match or exceed those obtainable with good electromechanical servomechanisms. Ultimate performance limits of the computing device are not yet known, but Elasco engineers estimate that performance improvements by factors of at least 2 or 3 will be obtained.

In physical size, the multipling element is approximately 2½ x 2¼ x 2¾ inches, packaged in a rectangular plug-in can. (This package does not include the associated power amplifier whose design depends a great deal on the application.) Potted construction provides exceptional ruggedness and resistance to severe environments.

The input signal A (Fig 3) is balanced against the output of bridge I, with the error applied to the servo amplifier. At balance the input impedance can be extremely high. Signals B and C feed input impedances of approximately 3000 ohms in the standard unit. Isolation amplifiers can be inserted where high resistances are required.

APPLICATIONS

The basic function of the unit, $D = A \times B/C$, suggests its application in the very numerous places where multiplication and division are to be performed. Specifically, the device is recommended in general purpose analog computers where high accuracy solid state computation is desirable in place of systems employing moving elements. The Elasco unit can substitute for a great many electromechanical potentiometer-type servomechanisms, at great savings of size and weight, and with improved reliability. It is also likely that the Elasco multiplier will find wide application in process industries where it should provide years of maintenance-free performance with no loss in accuracy.

Isolation of the separate bridges (Fig 3) suggests use of this device as an ac to dc, or dc to ac converter of high accuracy. In particular, note that ripple-free dc output is available without use of filters, in contrast with conventional phase-sensitive detectors. Converting from one frequency to another is also accomplished with ease. Squaring is accomplished immediately by letting $A = B$. Square root taking is carried out by an inverse process requiring an additional amplifier.

Write No. 244 in Box on Inquiry Card

LINEAR MOTOR

Unlimited Stroke Without Hydraulics or Pneumatics

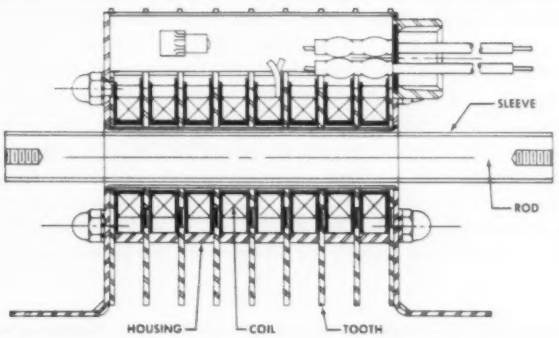
By varying the number of induction coils around an iron rod, Skinner Precision Industries, New Britain, Conn., has developed a unique electromechanical linear actuator that not only has many existing applications but may open the door to the application of new equipment design ideas.

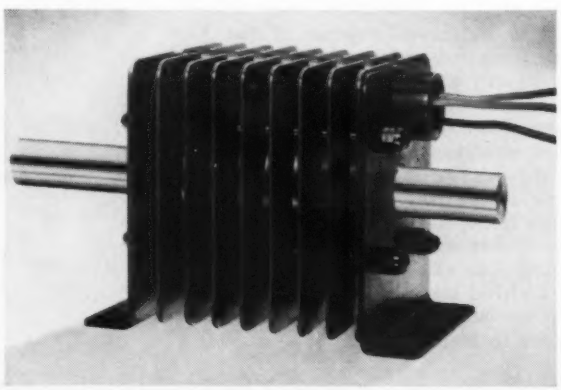
Called Polynoid, the device holds under load at any position or provides reciprocating motion. Stroke is up to six inches with standard units and is virtually unlimited with external guides. Output force, constant throughout the stroke in either direction, is directly proportional to input power.

Single and polyphase units are available, however, an external capacitor is required for single phase voltage. An even number of coils is used for single phase while coils in multiples of three provides polyphase operation.

Six models are available for testing and prototype use. Model O1A-12, rated ac voltage is 220-60; continuous duty holding force of 2.0 lbs (forces up to 16 times continuous rating are possible with intermittent duty).

Write No. 251 in Box on Inquiry Card





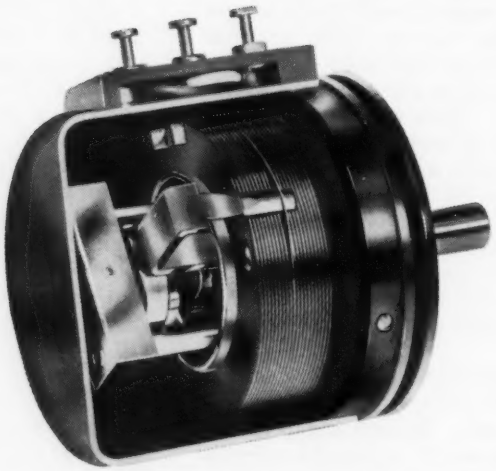


Fig 1 Cutaway view of Vico potentiometer showing novel construction of resistance element and wiper arm. Linearities of 0.01% are obtained in stock units of about 1 inch diameter.

ONE-INCH POT WITH 0.01 LINEARITY

New Wiper Design Removes Many Limitations on Pot Performance

The idea of a wire-wound potentiometer with infinite resolution would seem to most informed engineers to be self-contradictory. But designers at Vogue Instrument Co. of Brooklyn, N. Y. not only reveal how this concept is feasible, but describe a one inch stock model of such a pot with 0.01% linearity, low noise and long life (see Fig 1).

In a conventional wire wound pot, the resistance element is made by winding resistance wire in a tight coil on a card or mandrel and the wiper assembly is designed to slide the wiper over the coil. As the wiper passes across the wire from one turn to the next (see Fig 2), the output voltage of the pot makes a discrete jump. Thus, resolution, defined as the minimum distance the wiper must travel to achieve a change in resistance, is limited by the wire diameter. Good noise characteristics are also limited by the stepped nature of the resistance path causing successive interruptions of load and winding current.

But, why not use a simple linear wire instead of a coiled wire? The reason has been that to obtain effective resistance per unit length of resistance wire requires a wire so fine that a practical mechanism cannot be found for sliding a wiper over it.

Following conventional thinking to this point, Vogue engineers considered whether contacting the resistance wire from below, using a wiper mechanism that lifts the wire from the mandrel, would solve the problem. They found that applications of this technique in the design of a radically new mandrel and wiper mechanism profoundly reduced the limitations on use of fine resistance wire.

Figure 3 is a schematic representation of the Vogue design. A traveler supported wiper lifts the resistance wire from the thread of a precision-ground mandrel. The traveler moves along a lead screw precision-ground to the same pitch as the mandrel. Thus, lateral motion of the wire on the wiper is avoided, reducing wear and noise and improving linearity.

The result of this new design in conjunction with care in manufacture is a potentiometer of unusual performance capabilities:

- Linearities of 0.01% are obtained in stock units of about

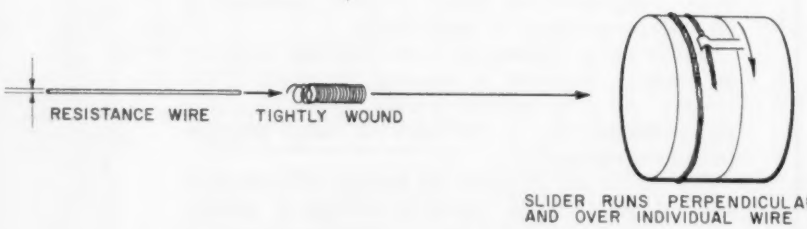


Fig 2 Basic configuration of the Vico pot compared with that of a conventional multi-turn wire-wound pot. In the conventional design the resistance wire is wound in a tight coil on a mandrel which is then wound in the form of a helix on a drum. The slider contacts the upper side of the coil and travels across the wire turns. In the new pot, a comparatively fine resistance wire is wound directly into closely spaced grooves on a cylindrical mandrel. The slider contacts the underside of the wire and travels along its length.

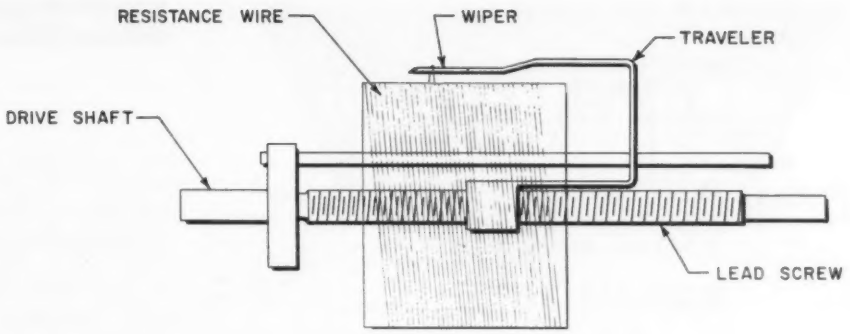


Fig 3 Mechanical schematic of the potentiometer illustrating its basic operating principles. The drive shaft rotates the lead screw causing the traveler to move in a helix whose pitch is identical to that of the wire on the mandrel. Contact to the wiper is made by a slip ring mounted on the inner circumference of the mandrel.

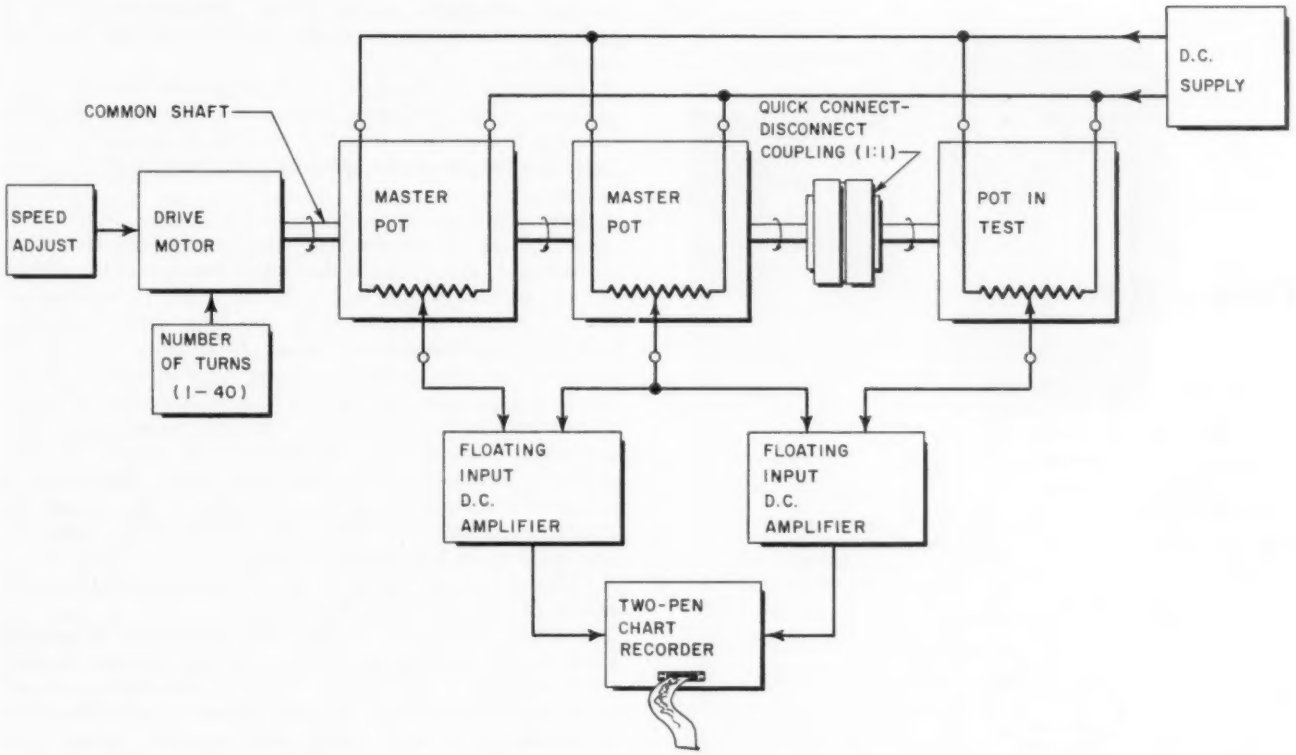
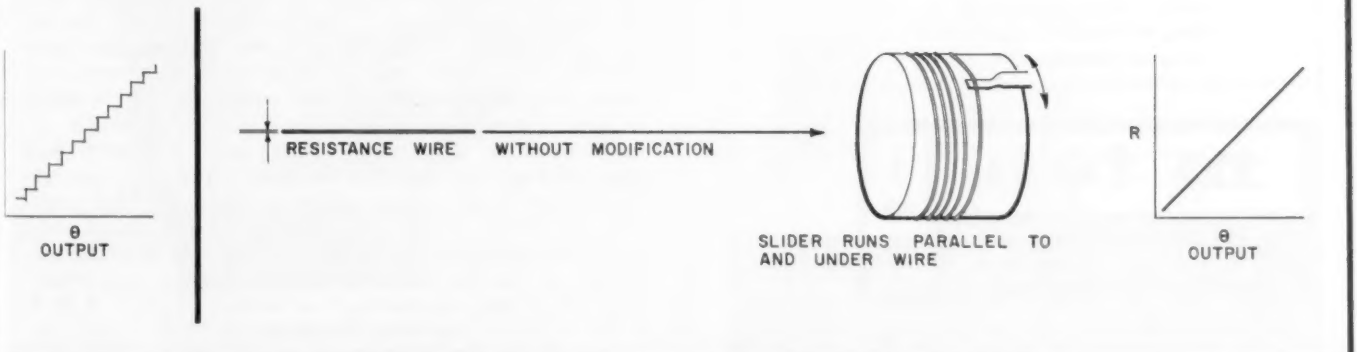


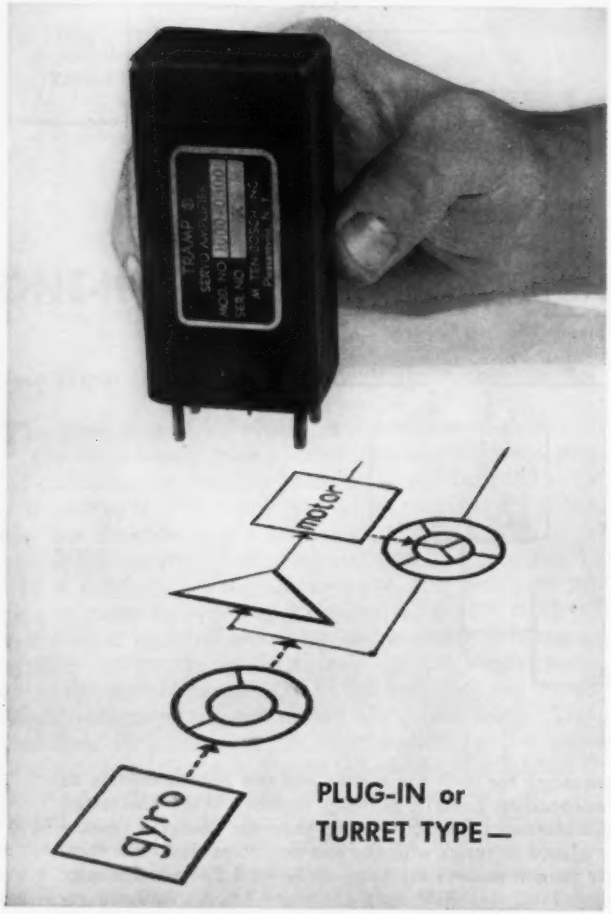
Fig 4 Test system for checking the specified 0.01% linearity of Vico pots in production. Two master potentiometers on a common shaft are checked during each test. The difference between the two masters — as well as the difference between one master and the test potentiometer — is recorded. This gives a constant check on the masters. In actual use trimming resistors are necessary for both the master and test potentiometers as independent linearity is being verified. When the tested potentiometer has fewer turns than the master a resistor is placed in series with the test potentiometer. The master potentiometers are large units with 0.001% linearity periodically verified by a six place Leeds Northrup resistance bridge.



Electronic Building Blocks
Series 1-TRAMP

Tramp®

will solve your servo amplifier problems just as easily



A transistorized building block that gives the design engineer—
- more than 1 watt controlled power per ounce
- voltage gains up to 30,000
- 10,000 hours of operation

Can be used in—
- differential DC applications
- magnetic amplifier applications
- relay applications

Hermetically sealed, meets government environment specs.

m. ten bosch inc.

For detailed TRAMP specs or R&D assistance, write to: Dept. TR-2, M. Ten Bosch, Inc., Pleasantville, New York

CIRCLE NO. 16 ON INQUIRY CARD

one inch diameter. A rapid production test measures the intrinsic linearity of each batch of resistance wire, eliminating wire variability as a factor.

- Noise effects due to a stepped winding are eliminated. Noise due to varying contact resistance is decreased orders of magnitude by the removal of stepped windings and worn insulation. Typical noise resistance at 100 rpm is less than 40 ohms at end of life. Contact resistance is less than 0.05% of terminal resistance. Selection of materials has also reduced noise. High velocity noise, which results from separation of the wiper from the resistance winding at high velocities, cannot occur. Triboelectric noise is reduced because the resistance wire is traversed along its length.
- Resolution has been found to be greater than the capabilities of the measuring equipment, 1 part in 300,000. Starting troque (less than 0.5 inch-oz) is also reduced by both the nature of the winding and manufacturing techniques.
- Inductance and capacitance are minimized in the new construction. In conventional wire-wound potentiometers, considerable inductance is developed because of the tightly wound nature of the wire. In the Vico potentiometer, the inductance is due only to the large helical winding and thus is reduced many times. Inductance seen at the terminals is even further reduced by the design of the slip ring which acts as a shorted turn coupled to the helical slide wire. In the conventional potentiometer, total stray capacitance results from capacitances of winding to case and of coil-to-coil of the resistance wire. The latter is completely eliminated in the new potentiometer, and capacitance to case is greatly reduced because of the decreased area of the resistance wire.
- Reliability is improved by greatly reducing the harmful effects of wire and insulation abrasion.

Another advantage of the new technique of special value to the computer designer is that considerably higher total resistance is permitted. Precision potentiometers are often used in cascade to provide successive multiplications of variables. In such usage, non-linearities result from potentiometer loading error due to the relatively low ratio between the loading potentiometer input resistance and the source potentiometer output resistance. The higher total resistance available in the Vico pot reduces loading error and provides more accurate computation in less space at less cost.

Vogue designers point out that selection of materials plays an important part in the reliability of a potentiometer. In their design the mandrel is a special epoxy or sufficient mechanical stability to allow precision grinding of the threads in which the wire lies. The temperature coefficient of the mandrel is very closely matched to that of the wire, so that any thermal variation in size has no first-order effect on linearity and does not produce wire stresses. The wiper and all other contact surfaces are made of precious metal and the resistance wire is made of any of a number of suitable high-tensile-strength resistance alloys. High-tensile alloys used are much less susceptible to corrosion than the annealed wires customarily used for tightly coiled resistance elements. This property, plus higher hardness and strength, adds considerably to potentiometer life. It is interesting to note that ultimate failure is due to the wire cutting through the wiper. Guaranteed life is in excess of one million cycles. • • •

For more information write
No. 245 in Box on Inquiry Card

ROTATING TRANSFORMERS

Frictionless Current-Transfer For Rotating Assemblies

To increase operating life and reliability, many designers of rotating electromechanical assemblies constantly search for ways to replace sliding contacts. The Instrumentation Lab. of M.I.T. has come up with a rotary transformer that can replace conventional contact-type slip rings and brushes in many of these assemblies.

Laboratory test data thus far has indicated that devices using these no-contact rotary transformers exhibit greater reliability, have longer operating life and shelf life, are plagued with less noise in low-level circuits and less wear in high-level circuits, and require less torque to turn any rotating member.

Developed by Randall L. Gibson, a Laboratory research engineer, the rotary transformer technique is based on the principle of physically separating the primary portions from the secondary portions by a small air gap, freeing the halves to rotate with respect to one another. When the primary portion is fixed to one structure and the secondary to another, the magnetic flux, set up by current in the primary winding, passes from the primary portion of the magnetic circuit through the air gap and into the secondary portion of the magnetic circuit, inducing current in the the secondary winding. The flux courses through the complete magnetic circuit via the air gap uninterruptedly, even when one structure – and, hence, a half of the transformer – rotates with respect to the other.

Magnetic circuits in the rotary transformers are fabricated from ferrite compounds because of the ease with which these materials can be handled, shaped, formed and ground. Size, shape and geometry of a rotary transformer depends on the job it is designed to do. To pass current into a rotating structure, the primary half of the trans-

Fig 1 Fixed primary portion of M.I.T's newly developed axial-type rotary power transformer.

FOR A QUOTATION ON AN

Environmental Chamber

TO MEET YOUR EXACT NEEDS,
fill out and mail this data sheet

TO: WEBBER MANUFACTURING CO., INC.
P. O. Box 217
Indianapolis 6, Indiana

Please submit a quotation, without obligation to me, for an environmental chamber with the following specifications:

DESIGN: Top opening_____(or) Front opening_____
INSIDE DIMENSIONS: left to right_____
front to back_____top to bottom_____
TEMPERATURE RANGE DESIRED:
from +_____°F to minus_____°F
PULL DOWN TIME DESIRED
from +_____°F to −_____°F in_____minutes
CHAMBER WITH HEATING CYCLE: Yes_____No_____
Heat Up Time from ambient (+80°F) to +____°F in____minutes
FORCED AIR CIRCULATION INSIDE OF CHAMBER: Yes____No____
INSTRUMENTATION: Indicating_____
Recording_____Programming_____
POWER REQUIREMENTS:
_____volts_____phase_____cycle
INTERIOR LIGHT: Yes____No____ **CASTERS:** Yes____No____
VIEWING WINDOW: Yes____No____Size_____
TERMINAL PANEL: Yes____No____
Number of Terminals_____Size_____
PORTHOLES: Yes____No____
Quantity_____Size_____
CHAMBER WITH HUMIDITY CYCLE: Yes____No____
CHAMBER WITH ALTITUDE CYCLE: Yes____No____
to_____Feet
COMMENTS: _____

Cut out and Mail

SEND YOUR QUOTATION TO:

NAME_____
MY NAME_____
COMPANY NAME_____
STREET ADDRESS_____
CITY_____ZONE____STATE_____
Have Your Representative Call Yes____No____

FREE BROCHURE!
This new 36-page brochure is the most helpful ever published for users of environmental chambers and low temperature freezers. It shows many of the types made by Webber—in any size, and with any temperature range.

WEBBER MANUFACTURING CO., INC.
P. O. Box 217 • Indianapolis 6, Ind. • Phone: MElrose 2-1378

CIRCLE NO. 17 ON INQUIRY CARD

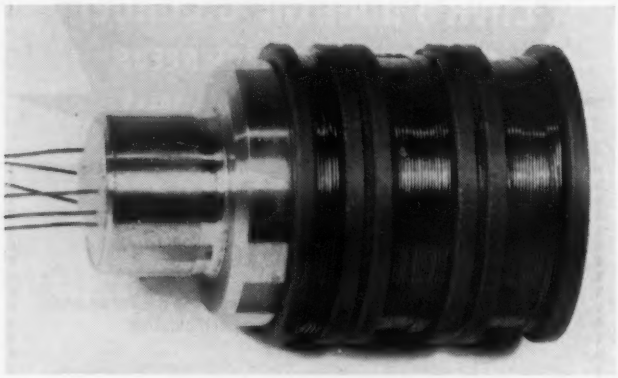


Fig 2 Rotating secondary portion of an axial-type rotary power transformer.

former is fixed to the non-rotating case or frame (illustrated in Fig 1) and the secondary portion to the structure itself (Fig 2). Just the reverse is true to extract current from the rotating structure.

Sets of rotary transformers can be stacked along an axis of rotation (see Fig 3) in applications where the length of the shaft is not particularly limited by other factors. In cases where shaft length is limited, sets of rotary transformers can be arranged in concentric circles around a particular point on the axis of rotation, as shown in Fig 4.

Ferrite rings and cup cores which make up the magnetic circuits are custom formed for any particular transformer design. Primary and secondary portions are initially assembled separately in metal holders. Epoxy resin is used to adhere primary and secondary windings to their respective ferrite portions of the magnetic circuit.

Finishing grinding, however, is performed on fully-assembled transformer units in order to avoid variations due to eccentric rotations. As a result, M.I.T.'s rotary

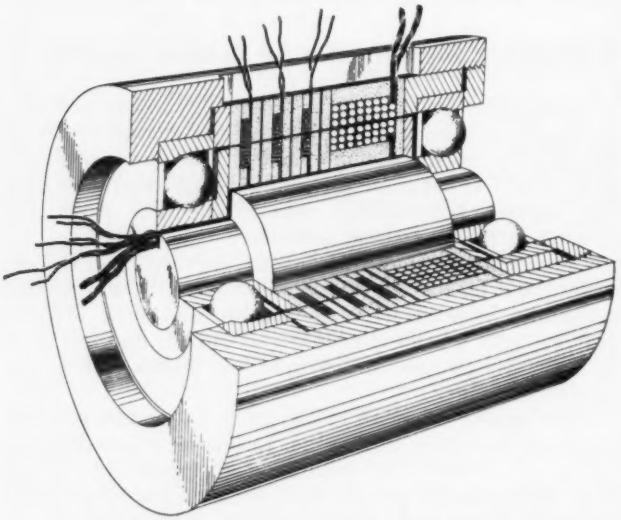


Fig 3 This rotating device includes an axial-type rotary power transformer (far right) and three axial-type rotary signal transformers. With ample space along the axis of rotation, primary and secondary portions of the transformers are arranged concentric to each other and stacked along the shaft.

Combine "Monoball"® Engineering Advantages with Life-Time Lubrication

Design engineers in many industries are specifying new "DYFLON"® SELF-ALIGNING and SELF-LUBRICATING SPHERICAL BEARINGS for these 5 major reasons:

1. LOWER COEFFICIENT OF FRICTION
...ideal where lubrication is impossible or undesirable.

2. WITHSTAND EXTREME VIBRATION
...perfect performance under shock load conditions.

3. WILL NOT "COLD-FLOW"
...even under extreme load conditions.

4. IMPERVIOUS TO KNOWN CHEMICAL SOLVENTS
...eliminates corrosion problems.

5. FAIL-SAFE ...due to "Monoball"® design.

Request Engineering manual No. 551.

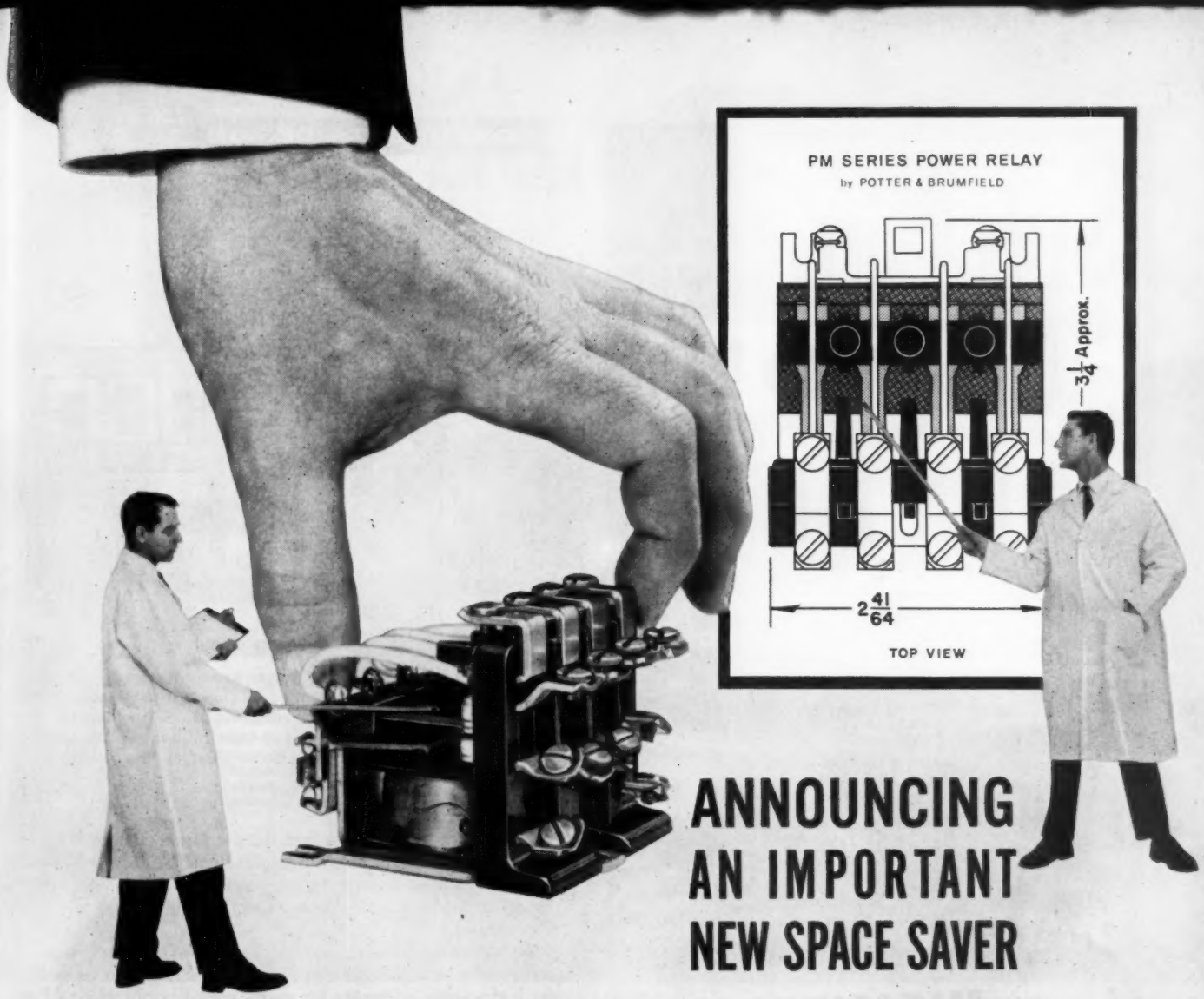
In addition, due to their two-piece "MONOBALL"® design and plastic alloy insert, "DYFLON"® bearings have a long cycle life. Alignment and installation problems are minimized. Oil-free for life means lowest possible maintenance costs.

Available in a variety of plain or rod end types. Bore sizes to 3.000". Materials include stainless steel, plastic alloys and chrome alloy steels. Ultimate static loads to 500,000 lbs.

SOUTHWEST PRODUCTS CO. 1705 SO. MOUNTAIN AVE. MONROVIA, CALIF. · PHONE: MURRAY 1-9616

CIRCLE NO. 18 ON INQUIRY CARD

CIRCLE NO. 19 ON INQUIRY CARD →



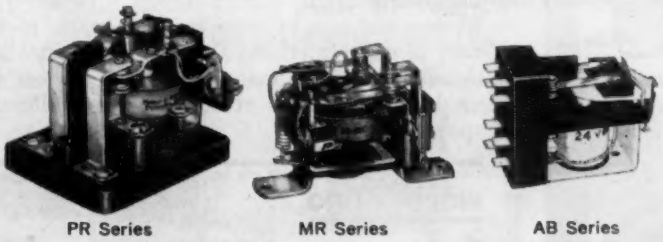
ANNOUNCING AN IMPORTANT NEW SPACE SAVER

P&B compact 4PDT power relay switches one H.P. per moveable arm

Save panel space! This new 4-pole relay is only 1/16" wider than our PR Series, America's most popular 2-pole power relay! Yet, it is engineered for reliable heavy-duty switching . . . and you can confidently expect 10 million mechanical operations.

PM Series relays are rated at 16 amperes (or 1 H.P.) at 115 volts, 50/60 cycles resistive . . . and special relays can be supplied for loads up to 25 amperes, at 220 volts, 50/60 cycles resistive. Heavy screw terminals are arranged for fast, easy hook up. An adapter plate is available for mounting PM relays in the same location used for 2-pole relays.

For full information, write today or call your nearest P&B representative.



PR Series MR Series AB Series

A whole family of power relays for a wide range of applications carry the P&B symbol of quality. Call P&B first for all your power relay requirements.

PM ENGINEERING DATA

GENERAL:

Description: Heavy-duty AC power relay.
Insulating Material: Molded phenolic.
Insulation Resistance: 100 megohms minimum.
Mechanical Life: 10 million operations minimum.
Contact Life: 100,000 operations minimum at rated load.
Breakdown Voltage: 2,000 volts rms minimum between all elements and ground.
Ambient Temperature: –55°C to +55°C.
Weight: Approximately 14 ozs.
Pull-In: 78% of nominal voltage.
Terminals: Heavy-duty screw type with No. 8-32 BH screw.

CONTACTS:

Arrangements: 4PDT or 4PST—normally open.
Material: ¼" dia. silver-cadmium-oxide.
Rating: 16 amps @ 115 volts, 50/60 cps resistive.
8 amps @ 220 volts, 50/60 cps resistive.
1 H.P. per moveable, 115 or 220 volts AC single phase.
25 amps @ 220 volts, 50/60 cps resistive available on special order.

COILS:

Voltage: 6 to 230 volts AC 50/60 cycles.
Power: 14 volt-amps average at nominal voltage.
Duty: Continuous.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONICS PARTS DISTRIBUTORS

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

Sub-Min. Widest selection of Pilot Lights – from DIALCO

T-2

NEON

HIGH BRIGHTNESS and REGULAR TYPES

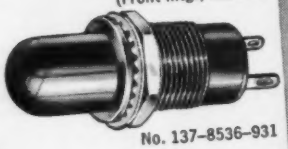
DIALCO's Sub-Miniatures use tiny T-2 Neon Glow Lamps: *NE-2J (High Brightness)* at 105-125 V., A.C.; or *NE-2D* (regular) at 105-125 V., A.C. or D.C.

NEW Series mounts from *FRONT* of panel in 15/32" clearance hole (supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 5 colors; give all-angle visibility. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-159C and L-160B.

(Illust. approx. actual size)

(Front mtg., 15/32")



No. 137-8536-931

(Front mtg., 17/32")

No. 145-5036-991

(Back mtg., 15/32")

No. 138-3836-1431-99

DIALCO

T-1¾

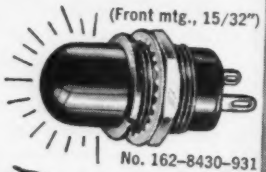
INCANDESCENT

2-TERMINAL and 1-TERMINAL TYPES

Designed for use with T-1¾ midget flanged incandescent lamps—1.3 V. to 28 V... *NEW* Series mounts from *FRONT* of panel in 15/32" clearance hole—(supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 7 colors. Units are fully insulated; meet applicable Mil. Specs.

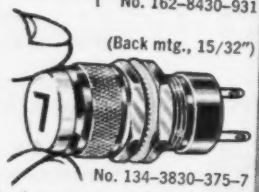
Ask for Brochures L-156D thru L-159C.

(Front mtg., 15/32")



No. 162-8430-931

(Back mtg., 15/32")



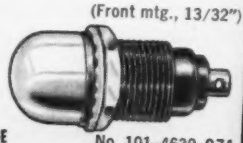
No. 134-3830-375-7

Spring-mounted Lens-with-Message is *rotatable*.

1-Terminal Pilot Lights

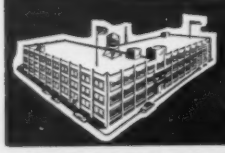
For use on *grounded circuits*. Mount in 13/32" or 15/32" clearance hole. Binding screw or soldering terminal.

(Front mtg., 13/32")



No. 101-4630-971

SAMPLES ON REQUEST—AT ONCE—NO CHARGE



Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

40 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

CIRCLE NO. 20 ON INQUIRY CARD

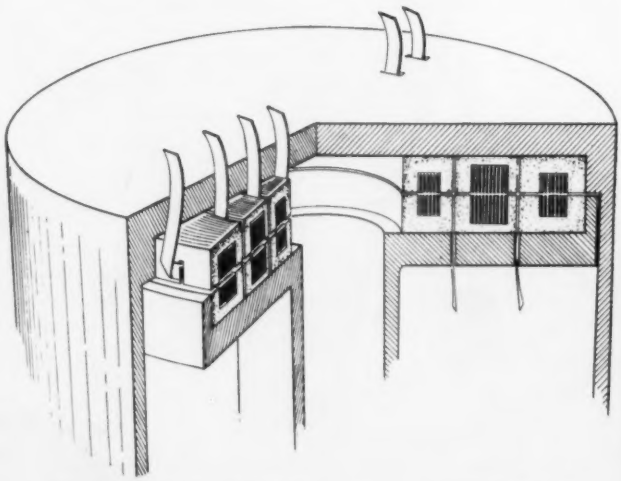


Fig 4 Three radial-type power transformers with primary (upper) and secondary (lower) portions arranged in mutually opposing rings. With limited space along the shaft, sets of transformers can be arranged concentrically around a point on the axis of rotation.

transformers have shown less than 0.1 per cent change of amplitude with rotation due to eccentricities in the finished rings. Grinding is done on conventional surface and cylindrical grinders with tolerances of 1/10,000th of an inch throughout.

Rotary transformers are not as efficient from a power standpoint as slip rings and brushes, but they can be made with efficiency adequate for many useful applications. For instance, prototype rotary transformers built at the Laboratory easily met a specification of 98% power efficiency.

Although they must be assembled, ground and mounted with care and precision, the transformers in finished form are extremely rugged, according to the Lab. report. Several were accidentally dropped to the floor – some as many as three times each – without performance impairment. Even if the ferrite structures which make up the magnetic circuits crack in a radial direction, performance is not affected.

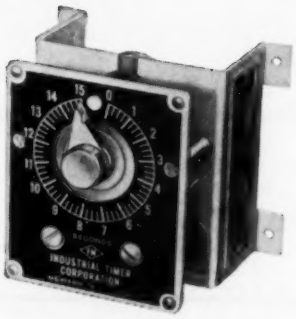
M.I.T. developed the rotary transformer as part of an overall research project aimed at reducing problems associated with the use of slip rings and brushes in pendulous integrating gyro accelerometers. However, the transformers can also be used in synchronous motors, in a variety of electromechanical attitude reference systems, such as autopilots, or in many frictionless devices such as those used to test satellite vehicles under conditions simulating space environment. • • •

WORTH FILING

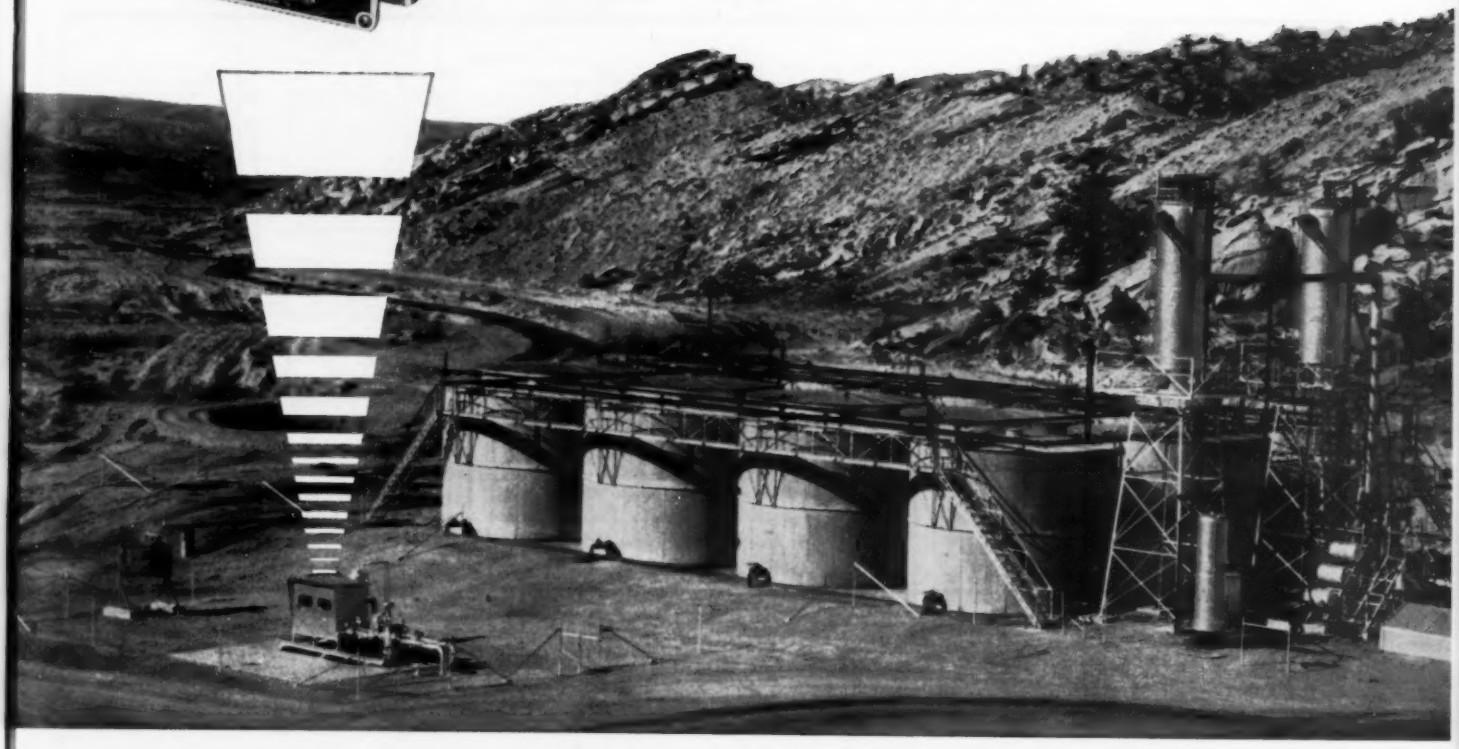
Flutter

A study of the phenomenon of flutter and its associated disturbances – wow and drift – in magnetic recording is available in a 12 page booklet. Its nature, cause and ways to avoid flutter are clearly presented. Basic elements of a flutter meter are also described.

Source: Amplifier Corp. of America
New York, N. Y.
For Your Copy: Write No. 809 on Inquiry Card



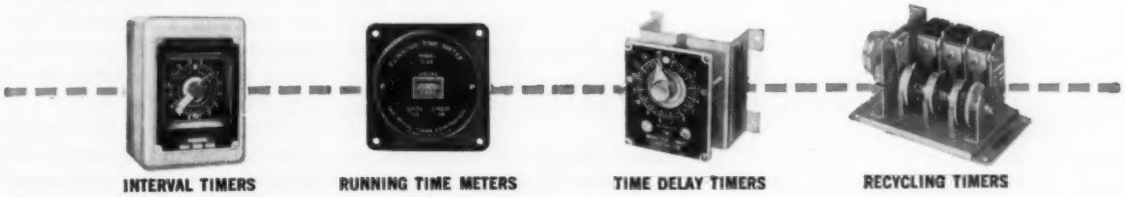
AN INDUSTRIAL TIMER TIME DELAY TIMER



at the heart of LACT *automatic crude oil handling*

In less than 5 years the "Lease Automatic Custody Transfer" system has become one of the significant advances that automation has brought to the oil fields. Unknown a little over 5 years ago, there are now more than 200 National Tank Company LACT systems speeding the handling of crude everywhere in the oil country. Governing the system is a Backwash Filter Programmer Control Panel, by Instruments, Inc. . . . and at the heart of the panel, an Industrial Timer Corporation Series SF time delay timer.

Wherever precise timing controls are required for industrial processes or in equipment, Industrial Timer Corporation has the wide range of precision instruments and the wide experience to meet your need. If timing is of the essence . . . take the time to consult an Industrial Timer expert. Phone or write us.



INTERVAL TIMERS | RUNNING TIME METERS | TIME DELAY TIMERS | RECYCLING TIMERS

INDUSTRIAL TIMER CORPORATION
1405 McCarter Highway, Newark 4, New Jersey

Manufactured and sold in Canada by
SPERRY GYROSCOPE OTTAWA LIMITED • 3 Hamilton Ave., Ottawa, Canada • PA 8-4681

CIRCLE NO. 21 ON INQUIRY CARD

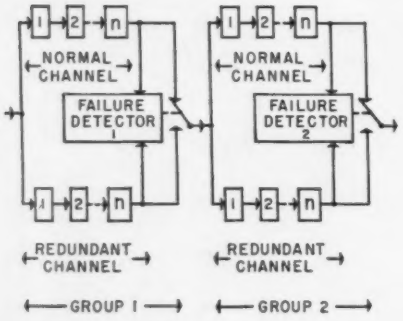


Fig 1 A two-group redundant system having an input to both a normal and a redundant channel with a failure detector across the channel outputs of each group.

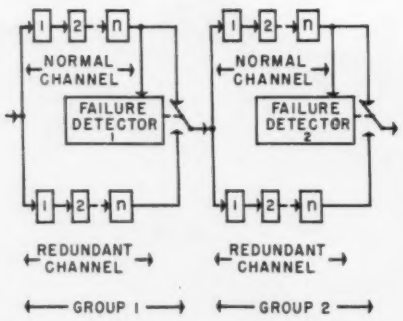


Fig 2 A two-group redundant system having an input to both a normal and a redundant channel with a failure detector across only the normal channel output of each group.

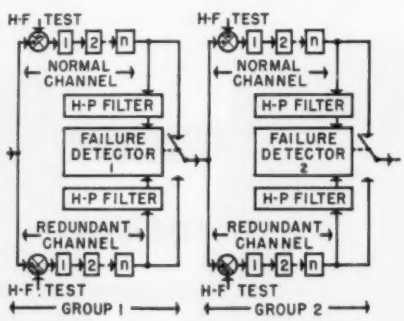


Fig 3 A two-group redundant system with high-frequency test signal input to both normal and redundant channels. High-pass filters reject the low-frequency intelligence information of the control systems, passing only high-frequency test information to the failure detector.

GROUP REDUNDANT SERVOS

Failure Detection and Switching Circuits for Redundant Systems

Increasing the reliability of systems by concentrating on improvement of components is severely limited by the "state of the art" of components. A far more powerful tool being employed in many new systems is the group redundant technique which combines single elements into logical functional groups operated in parallel. A failure detector used at the output of each group switches from a normal channel to a redundant channel upon failure of the normal channel.

S. Adelman and S. Shinners of the Sperry Gyroscope Co., Great Neck, L.I. N.Y. have found this technique applied to feedback control systems improves reliability dramatically with a relatively small increase in overall engineering effort. For example, they estimate that in a servo control system for a tracking radar designed at Sperry, use of group redundancy increased reliability by a factor of 2,667.

FAILURE DETECTION AND SWITCHING

Application of failure detection and switching techniques in development of group-redundant feedback systems imposes problems peculiar to such systems: under steady-state conditions the control signals are very small (in the noise region) whereas under dynamic conditions they can be quite large, moreover a wide range of signal frequencies are normally encountered.

Adelman and Shinners describe four methods of failure detection and switching that can be used in feedback control systems:

1. The input is applied to both the normal and redundant channels and a comparator-type failure detector is connected across the channel outputs. When a difference between the two outputs is detected, failure detection and switching circuits determine which channel is faulty and connect the good channel into the system (see Fig 1).
2. The failure detector is connected to monitor continuously only the operating channel. If the operating channel fails, the redundant channel automatically replaces it in the system (see Fig 2).
3. A test signal at sufficiently high frequency not to interfere with normal operation of the servo system is fed through both the normal and the redundant channels. High pass filters allow only the high frequency test signals to pass to the failure detectors which monitor performance and initiate desired switching. In evaluating this method for a given application the designer should calculate whether the system error contributed by the external test signal is within specifications. A disadvantage of this method is that since it only monitors the system's response to high frequency components of the input, it is not a completely dependable check on overall performance. For example, it would not indicate a failure if the feedback capacitor of a dc operational amplifier, being used as an integrator, had short circuited (see Fig 3).
4. The operator of the equipment monitors failures in the normal channel and switches to the redundant channel when he determines a failure. This method is advisable where the necessary failure detection circuitry would be more complicated than the channel to be monitored. An example of such a situation is in the track loop of a tracking radar which because of sev-

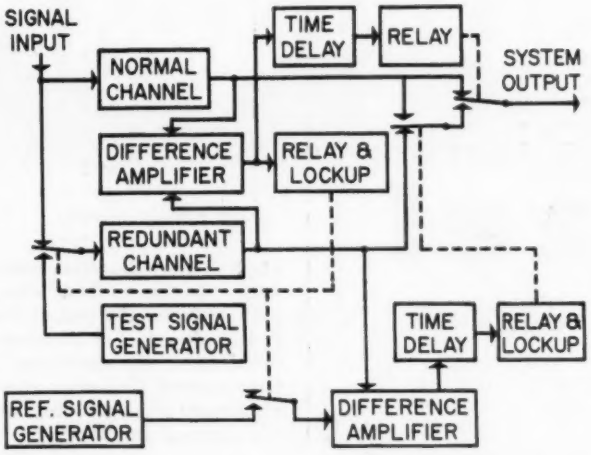
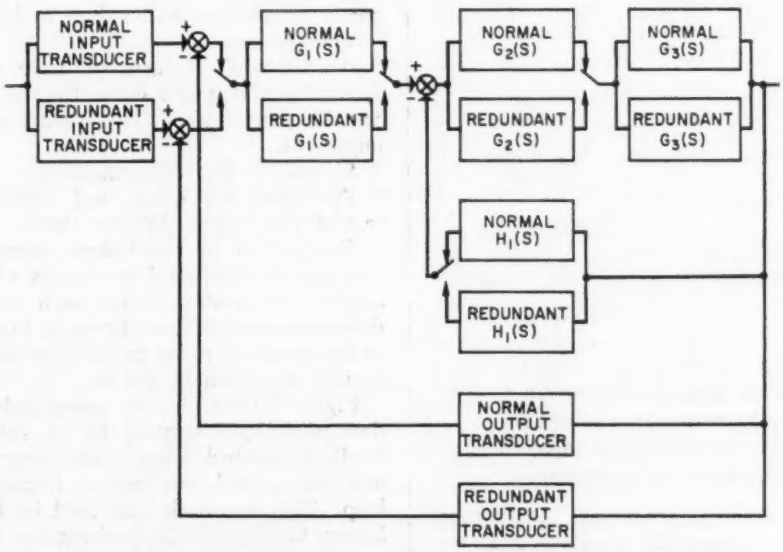


Fig 4 Failure detection circuit using differential amplifiers. When a failure occurs in one of the channels, the difference amplifier monitoring the two channels senses a failure and trips a relay and lockup circuit which disconnects the redundant channel from the system input and momentarily connects it in a test circuit for the period of a test cycle. The failure signal from the difference amplifier also triggers the relay at the system output, after a time delay to allow completion of the test cycle. The test circuit compares the output of the redundant channel, driven by a test input signal, with a reference output signal by means of a second difference amplifier. *If the redundant channel has failed*, the second difference amplifier feeds a signal (through a time delay to prevent switching transients from indicating failure falsely) to actuate a second relay and lockup which disconnects the redundant channel from possible continuity with the load and connects the normal channel with the on-contact of the relay at the output. Then when the relay at the output actuates, the normal channel maintains connection with the load. *If the redundant channel has not failed*, the difference amplifier in the test circuit does not actuate its relay and lockup circuit and the redundant channel will be connected to the load when the relay at the output actuates.



GROUP REDUNDANT APPROACH IN FEEDBACK CONTROL SYSTEM

Fig 6 In this system as in most group redundant feedback control systems both power drives are connected in the system and are rated to operate at ½ power during normal operation. Then on failure of either channel the other operates at full rated load.

Now available from Helipot at the lowest price in history!

Model 70 with Teflon leads, $5.35 and down; Model 71 with pins, $5.95 and down.

Take your pick: Model 70 with leads... Model 71 with pins. They'll solve your trimming and space problems and see you through adverse environmental conditions, too!

They're the best pair of square trimming pots on today's market ...at this or any price!

The reasons?

Elementary... they offer special features (such as Teflon leads on the 70) as standard! And both standard models incorporate a unique slip clutch stop that positively prevents the wiper from going off the end of the coil and into dead space. (Continuous units are available as special.)

The specs tell the story! Standard resistance ranges of 10 to 50,000 ohms... resolution from 1.01% at 10 ohms to 0.083% at 50K ohms...1 watt power input at 50°C derating to zero at 150°C!

And all this performance is packed into a 1/2" square all-metal housing that's sealed against humidity.

Your local Helipot representative carries these pots in stock for immediate delivery. Call him.

Beckman® / Helipot®

POTS : MOTORS : METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

© 1961 B.I.I. 61102

CIRCLE NO. 22 ON INQUIRY CARD

check this for
SIZE!

SERVOS AND SYSTEMS

Designed from an overall specification . . . manufactured from your own assembly drawings...SUPERIOR's carefully co-ordinated design, performance and point-by-point inspection, creates Servo packages and systems with always dependable, SUPERIOR performance.

GEAR HEADS & REDUCERS

The finest, most complete line of standard gear heads and speed reducers . . . plus special units engineered specifically for individual needs . . . produced with accuracy and speed, in the SUPERIOR way.

INSTRUMENTATION

SUPERIOR's creative design brings new units to advance the testing, controlling and teaching of servomechanics. The finest new electro-mechanical instrumentation is always SUPERIOR.

* MINIATURE SERVO ASSEMBLY

WRITE TODAY FOR **FREE** CATALOG

*The assembly shown above is part of a sophisticated system requiring the maximum in performance and reliability. It's typical of a SUPERIOR solution to a customers space problem. The engineering know-how of SUPERIOR in the field of servo-mechanics can add to the total capabilities of its customers.

superior
manufacturing and instrument corp.

36-07 20th Ave., Long Island City 5, New York

CIRCLE NO. 23 ON INQUIRY CARD

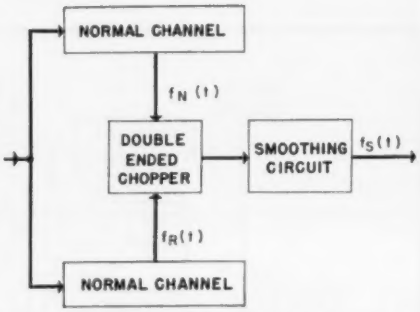


Fig 5 Failure detection using pulse modulation. In this method, when either channel has failed the output from the detector is reduced. For adequate operation of the detector the smoothing circuit should have a cutoff frequency above the highest component of signal frequency, and below the chopper frequency.

eral modes of operation requires a large amount of switching for a multiplicity of transfer functions.

Failure detectors for group redundant systems require the most critical consideration and design. Adelman and Shinners list 5 major characteristics of a good failure detector for a feedback control system:

- Fast response so that a defective unit may not damage another part of the system. For example, this characteristic is imperative in the power drive portion where a defective component could cause serious and widespread damage.
- Capability of detecting marginal to catastrophic failures. Detecting marginal failures in a feedback system is difficult since the signals to be compared range from null values to high-level transients.
- A "fail-safe" feature, to leave the system operating with either the normal or redundant channel. This is extremely important.
- Simplicity, for high reliability.
- Provisions for quick and effective test of the failure detector itself.

Comparison in the failure detector may be accomplished by means of a simple comparator circuit such as a difference amplifier, as shown in Fig 4, or by means of pulse modulation techniques, as shown in Fig 5.

Figure 6 illustrates the group redundant technique applied to an entire feedback control system consisting of one major and one minor feedback loop. This approach was used by the Sperry Gyroscope Co. in designing the servo portion of a naval tracking radar system. Adelman and Shinners say that this servo system has never been out of commission due to failure since it was put in operation over a year ago.

Write No. 167 in Box on Inquiry Card

Response-ability!

plus reduced size and weight

ACTUAL SIZE
(versus ordinary commercial servo-type motor)

EAD 60 CYCLE MINIATURE SIZE 15 SERVOMOTORS

Design *instant response* into your recording instruments and, at the same time, miniaturize your "package" with substantial cost-reductions. EAD 60 cycle, size 15 miniature servomotors are engineered for RESPONSE-*ability*... the ability to produce rapid acceleration and reversing without over-power and over-size.

These 60 cycle, size 15 servomotors, now available for commercial applications, have the same precision RESPONSE-*ability* as EAD's military versions...your assurance of high performance and reliability.

TYPICAL PERFORMANCE DATA

MODEL	VOLTAGE	FREQUENCY	STALL POWER/ PHASE	STALL CURRENT/ PHASE	TIME CONSTANT	REVERSING TIME	ROTOR INERTIA	NO LOAD SPEED	STALL TORQUE
S2HBZ7-*	115 volts	60 cycles	6.0 watts	70 MA	.0052 Sec.	.0089 Sec.	4.0 gm cm²	1500 RPM	1.7 oz-in
S2HAX7-*	115 volts	60 cycles	6.0 watts	70 MA	.00915 Sec.	.0155 Sec.	3.3 gm cm²	3000 RPM	1.6 oz-in

*Basic models. Mechanical modifications available to customer requirements.

If your responsibility is improved recorder design, look first to EAD for the servomotor line that meets all your RESPONSE-*ability* requirements. Call your nearest EAD representative or write about your specific needs.

Rotation Is A Science At

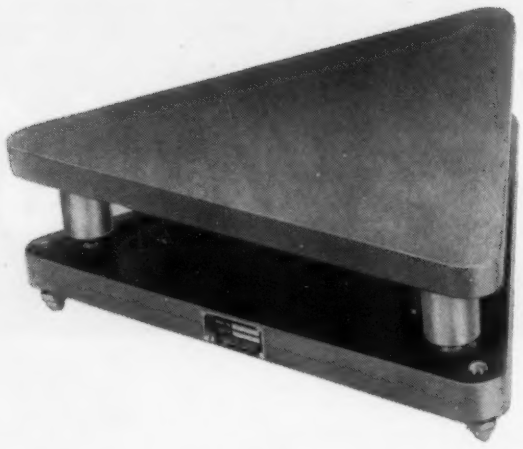
EASTERN AIR DEVICES, Inc.

A SUBSIDIARY OF NORBUTE CORPORATION

353 CENTRAL AVE., DOVER, NEW HAMPSHIRE

CIRCLE NO. 24 ON INQUIRY CARD

TESTING



VIBRATION ISOLATION TABLE

Ball Bearing Supports Isolate Sensitive Equipment from Horizontal Vibration and Motion

Isolation of sensitive equipment from horizontal motion or from rotational motion about a vertical axis is effectively maintained by a new vibration isolation table with a unique three-point ball bearing support. The accompanying diagram and caption describe the operation of the support mechanism which isolates the platform from motions of the base or the base from motions of the platform up to a maximum of ½ inch excursions.

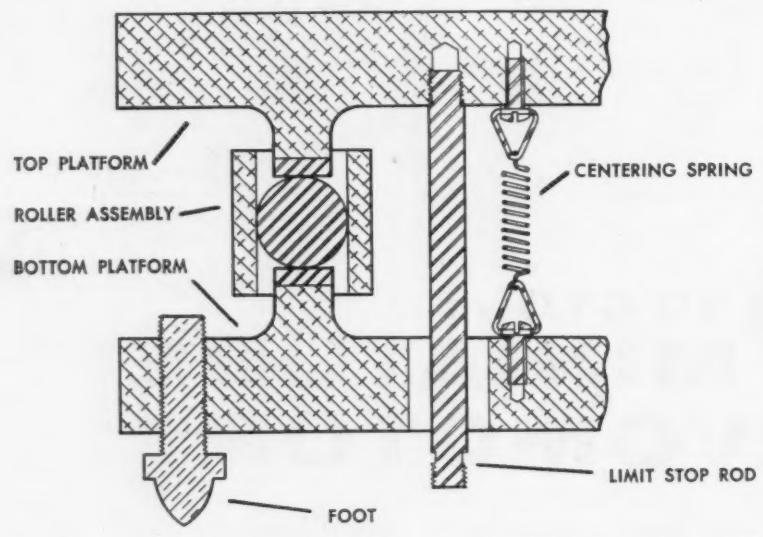


Fig 1 Cross section of one of the three roller assemblies that support the platform. Dimensions of all vital parts have been calculated to within a thousandth of an inch from the measured material densities. The polished steel ball is held firmly in position by compression of the outer aluminum cylinder and cannot move with respect to the cylinder. The polished steel pads that rest on the ball serve as bearing surfaces for the ball forming in effect a three-point ball bearing support for the top platform. Design of roller assembly is such that its radius of gyration about any axis through its center is equal to the radius of the ball. Then, any two opposite points on the ball will be complementary centers of percussion. For example, motion of the bottom platform towards the right will impart a linear acceleration of the center of mass of the roller assembly towards the right and a counter clockwise angular acceleration of the entire roller assembly. The center of mass of the roller assembly would have a net motion towards the right, but of a lesser magnitude than the motion of the bottom of the ball. With the radius of gyration equal to the radius of the ball, the angular and linear accelerations cancel each other at the top surface of the ball, and the horizontal force imparted to the top platform is zero. Restraint by the top platform is not involved in the operation of the roller assembly. Springs prevent gradual drift of the top platform with respect to the bottom platform. The limit stop rod extends through a hole in the bottom platform preventing excessive motion of the top platform, but allowing a peak to peak excursion of ½ inch.

Applications of the table, manufactured by Tenlo Research, Inc., of Minneapolis, Minn., include isolation of sensitive electrical and mechanical instruments such as galvanometers, electrodynamometers, balances, surface roughness measuring devices, optical benches and other sensitive equipment. It can also be used for testing and calibration of servo mechanisms, accelerometers, and other sensors by removing spurious horizontal components from a generated vertical acceleration or vibration.

The table should normally be used for support of an entire instrument. For example, an optical readout galvanometer complete with a light source and reading scale can be operated on the top platform without difficulty. However, because the top platform is free to rotate about a vertical axis, a galvanometer or other instrument placed on the top platform should not be used with a separately mounted remote optical reading device. In such situations the use of two platforms mechanically connected so as to form effectively a single long narrow platform is recommended. One platform is used to support the instrument, and the other to support the readout device. A simple metal channel may be used to mechanically connect the two individual platforms. Because of the high horizontal compliance of the TBV-1 table, and its lack of a caging mechanism, it is intended primarily for applications where the supported device doesn't need to be touched or manipulated.

The table may be precisely leveled and will remain level for an indefinite period of time. There is no elastic or other resilient support which may change or fatigue with age. When the table has been once leveled, the angular attitude of the top platform will not change. • • •

Write No. 160 in Box on Inquiry Card

SWEEPING OSCILLATOR

Accurate Low Frequency Testing Using RF Techniques

Until now, low-frequency sweeping oscillators have not been in wide use. This is primarily due, according to Kay Electric Co., to the lack of stable, accurate markers and the difficulty of obtaining a clear, easily interpreted response envelope at audio frequencies. The Pine Brook, N.J. company, however, has developed a low-frequency sweeping oscillator that provides these most useful characteristics.

Called the Sona-Sweep Model M, the unit adapts the accepted techniques of RF swept-frequency alignment for audio and ultrasonic design and test work. Ultra-stable response curve, developed by the Sona-Sweep, permits easy observation of response characteristics of the tested circuit or component.

Sona-Sweep provides a complete measurement system, including logarithmic, linear and manual sweeps or a calibrated C-W signal; sharp, "crystals;" pulse-type frequency markers; built-in audio detector; and precision step-attenuator. The clean, detected envelope of audio-frequency bandpass characteristics clearly defines amplitude-vs-frequency. The increase in trace intensity provided by the detected signal (rather than by a diffused a-f pattern) makes it much easier to view the response characteristics and to monitor any adjustments of the circuit under test.

A double-heterodyne system produces linear or logarithmic sweeps with continuously variable center-frequency between 20 cps and 200 kc. A manually swept output, within the same range covered by the sweep generator, may be used to examine in detail the response characteristics of narrow passband waveforms produced by audio filters and high-Q circuits.

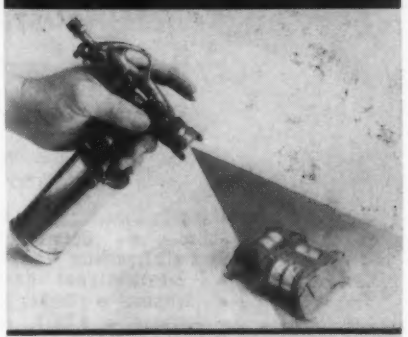
When the Sona-Sweep is used in conjunction with an electronic counter and accurate voltmeter, frequency measurements of passband, db-down points, etc., may be determined with accuracies limited only by the counter.

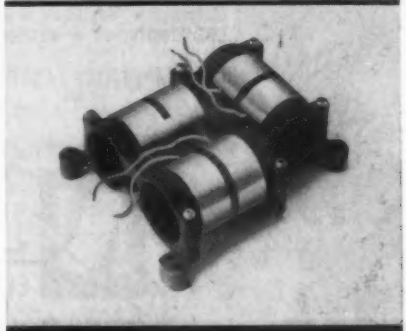
For checking high-Q and low-frequency response characteristics, variable rep-rates between 0.2 cps and 25 cps are available. This wide choice of sweep rates, plus a 30-cycle lock, enables selection of the optimum rep-rate which gives an accurate response display of the circuit being tested and easy viewing on the scope screen.

The instrument delivers a high-level output of 5 volts rms into 600 ohms over the entire frequency range. Built-in, precision step-attenuator provides up to 59 db of attenuation in discrete steps, plus 6-db variable increment. Output is flat to ±0.5 db.

Write No. 162 in Box on Inquiry Card

Electrofilm





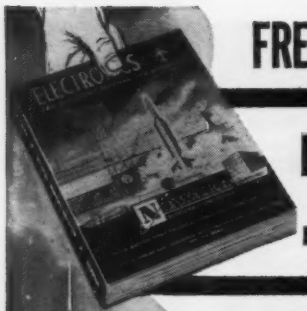
SPRAYED-ON HEATING ELEMENTS

Electrofilm's sprayed on — film type heating elements are especially designed for hard to heat contour surfaces. The element can be applied directly to the part . . . or to detachable components.

- **LIGHT WEIGHT** .07 lbs./sq. ft.
- **THIN** .011" to .015" (approx.)
- **ENVIRONMENT** Meets mil E-5272-A Spec.

Write for detailed technical data.

Electrofilm INC.
P.O. BOX 106, NORTH HOLLYWOOD, CALIF.
CIRCLE NO. 47 ON INQUIRY CARD



FREE! the Catalog that has everything in

ELECTRONICS
for
INDUSTRY, DEFENSE, BROADCAST

452 pages!

Semi-Conductor Headquarters For Industry at Quantity Prices Competitive with Manufacturers

Texas Instruments • Hughes Philco • General Electric General Transistor • Bendix • International Rectifier • Sylvania • Sarkes Tarzian • Hoffman • I.T.&T. • RCA Motorola • Raytheon • Ohmite CBS Electronics • Westinghouse

Newark stocks and distributes over 450 top lines covering every phase of electronics!

Semi-Conductors • Connectors Relays • Switches • Industrial Tubes • Test Equipment Transformers • Controls Resistors • Meters • Capacitors • Pilot Light Assemblies

★ COMPETITIVE FACTORY PRICES ★ COMPLETE ON-HAND STOCK
★ IMMEDIATE DELIVERY

Your One-Point Source for All Your Electronic Needs

NEWARK
ELECTRONICS CORPORATION

Dept. EL-6

223 W. Madison St., Chicago 6, Illinois
4747 W. Century Blvd., Inglewood, California

CIRCLE NO. 25 ON INQUIRY CARD

Electroplated WIRES

We plate wire continuously with unusually high uniformity throughout the length of wire. . . . Gold, Silver, Nickel, Rhodium, Indium, Tin and many other metals, or combinations of metals, are plated onto wires of Tungsten, Molybdenum, Nickel, Bronze, Copper, Silver, etc. . . . The purity of the metals and the quantity deposited are reliably controlled within narrow limits.

Write for Latest Brochure

SIGMUND COHN MFG. CO., INC.
121 SO. COLUMBUS AVE., MOUNT VERNON, N. Y. Since 1901

CIRCLE NO. 26 ON INQUIRY CARD

TESTING

AC/DC Converter

Automatically selecting the appropriate ac voltage range an ac/dc converter ideally suits automatic data logging and system testing jobs where a wide range of ac voltages need to be measured. Used with a digital voltmeter, the instrument displays readings of four digits. Input voltage range is 1 mv to 1000 volts, in steps of 9.999/99.99/999.9 volts ac. Input impedance: 10 megohms. Output voltage falls within 0.01% of final value in less than six sec for full scale excursion even at the lowest frequency (30 cps). Non-Linear Systems, Inc., Del Mar, Calif.

Write No. 742 in Box on Inquiry Card

AC/DC To DC Comparator

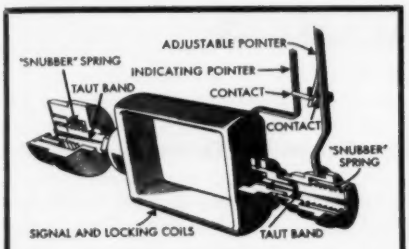
Said to be novel and unique and never before available, an instrument extends application of ordinary oscilloscopes into the realm of a precision waveform comparator and analyzer. The ac/dc to dc comparator is a precision summer-limiter-amplifier-limiter based on operational amplifier techniques. Peak ac may be compared to dc with 0.005% comparison accuracy, dc to dc with 0.001%. In addition to calibrating ac and dc standards, the comparator makes possible precision observation of small selected portions of large waveforms without oscilloscope overload. Rotek Instrument Corporation Cambridge, Mass.

Write No. 744 in Box on Inquiry Card

Power Supply Test

For measuring dynamic response time and load switching transients in power supplies, a low cost, simple test instrument, developed by Elasco, Inc., Roxbury, Mass., generates one-half millisecond, 0-1 amp pulses, with a repetition rate fixed at 20 cycles. Magnitude of the current pulse, varied by a control knob, is read directly on a meter included with the instrument. Available in two models, permissible voltage ranges are 2 to 50 volts and 2 to 400 volts. Simplicity of test operation makes the instrument particularly useful for incoming power supply inspection or on-line production testings and for checking power supply performance characteristics where critical parameters may be tied in with other operating units of a system.

Write No. 726 in Box on Inquiry Card



Meter-Relays

Taut band movement in meter-relays eliminates friction to provide full-scale sensitivities in the area of 0 to 5 microamperes or to 0 to 2 millivolts and offer great accuracy and repeatability in the range of 50 microamps or less. Extra torque to lock pointer contacts, when the set point is reached, is supplied by a booster coil. Current to the locking coil passes through one of the two torsion bands that suspend the meter coil. Coil springs, coaxial with the taut bands, are incorporated in "snubber" mechanisms at both ends of the meter movements. Under shock and vibration, the "snubbers" keep the taut band system aligned. Assembly Products, Inc., Chesterland, Ohio.

Write No. 737 in Box on Inquiry Card

Dynamic Servo Analyzers

Designed for checkout of missile and aircraft servo controls systems in the factory or field, solid-state analyzers combine the functions of signal generation, dynamic servo-response analysis an data presentation while minimizing measurement errors caused by harmonic distortion, noise and dc offset in the servo output signal. Frequency-response test time is reduced to the time period required for a single cycle of each test frequency plus ½ second. Giannini Controls Corp., Duarte, Calif.

Write No. 727 in Box on Inquiry Card

Digital Voltmeter

Voltmeter indicates dc voltage to 4 digits with linearity of 0.01% of full scale. Applied voltages automatically select appropriate range (±10, ±100, ±1000v), polarity sign and decimal point. It can be locked into any one range to facilitate rapid, repeated measurements. Sensitivity is better than 1 mv. Readings are also available in 1-2-4-8 binary-coded signals. Self-adjusting stepping switch drive employs sealed reed relays in place of thyratrons to ensure quiet, smooth operation. Beckman Instruments, Inc., Richmond, Calif.

Write No. 748 in Box on Inquiry Card

Digital Voltmeter

Reading the average value of voltage applied over a definite, selected sample period effectively eliminates noise and hum effects in a new integrating digital voltmeter. Range, sample period and rate are externally programmable by simple contact closures to assure maximum flexibility. Binary-coded decimal output drives recording and control equipment. Input guard circuitry greatly reduces the effect of common mode ac pick-up between the signal source and the meter. Stability is better than 0.01%/day on the 1 volt range and above, and the overall accuracy is 0.05% nominal. Dymec, Palo Alto, Calif.

Write No. 739 in Box on Inquiry Card

Edgewise Meters

Three-inch edgewise dc and ac meters have been developed for use in control console and equipment applications where reliable indication is required under severe environmental conditions. The hermetically sealed instruments are available in wide dc current (200 micro-amperes and up) and voltage ranges, as well as in rectifier-type ac. Internal mechanism is magnetically shielded. Minneapolis-Honeywell Regulator Co., Manchester, N. H.

Write No. 741 in Box on Inquiry Card

Portable Magnetometer

Low-cost magnetometer detects and measures magnetic field changes ranging from 5 to 5,000 gammas. Having power consumption as low as 0.1 w (supplied by Hg cells) and a wide dynamic range, the device uses a single fluxgate magnetic sensor. Field cancellation control cancels known magnetic fields so that the instrument measures only actual changes. Minneapolis-Honeywell Regulator Company, Boston, Mass.

Write No. 747 in Box on Inquiry Card

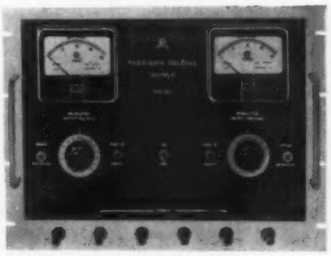
Diode Tester

Highly sensitive diode tester, with expanded capabilities in the low current and high voltage ranges, is a back-current and saturation voltage tester with meter ranges of 0 to 3000 volts, 0 to 3000 microamps, and 0 to 3000 milli-microamps. Regulation is better than 0.1%; ripple and noise, 0.05%. Output current is 0-1 ma; output voltage, 0-3000 volts. Trans Electronics, Inc., Canoga Park, Calif.

Write No. 749 in Box on Inquiry Card

J·R·L

THE LEADER IN ACCURACY



VOLTAGE REGULATED POWER SUPPLIES 50-100 TIMES HIGHER THAN STANDARD CELLS — ACCURACY 0.002%.

Julie Research Laboratories Precision/Stable Power Supply provides voltage levels 50-100 times higher than standard laboratory cells at essentially greater accuracy and stability.

Carefully selected zener reference diodes and high stability oil-immersed sensing and standardizing resistors are mounted in a special isothermal oven, permitting transfer of the basically high diode accuracy to the absolute voltage setting, and assuring exceptional stability for eight hours or more.

ACCURACY
0.002% — 8 hours
0.005% — Absolute

UNUSUAL INSTRUMENT FEATURES

- Self Calibration
- High Thermal Stability
- Dual Channel Design
- Low Impedance
- Exceptional Long-Term Accuracy

The PVS power supply is available in production quantities. Call or write for detailed technical specifications.

J·R·L JULIE RESEARCH LABORATORIES, INC.

603 West 130th Street
New York 27, N.Y.
Telephone: AUdubon 6-9200

CIRCLE NO. 28 ON INQUIRY CARD

U.S. Air Force photo.

B-58's transmitter —"a kilowatt in a capsule"—uses Bristol choppers

The HC-101 Communication System, HACON, designed and built for the U.S. Air Force by Hughes Aircraft Company, Culver City, California, is the world's smallest airborne 1000-watt HF Receiver-Transmitter. This small, lightweight, high-performance transceiver was made possible through the use of high-quality components, such as the Bristol Syncroverter* Chopper.

The Syncroverter Chopper is used as the d-c to a-c converter in the servo tuning system of the HACON Automatic Power Amplifier and was chosen because of its compact size, light weight, low noise, and ability to perform properly under the extreme environment produced by immersion in boiling fluorochemical.

In this application, the chopper has measured up to all expectations and has passed all acceptance and qualifications tests required of it.

The Bristol Syncroverter Chopper is used in a tremendous variety of airborne and missile-borne equipment—including literally dozens of missile guidance systems. On these exacting applications, the Syncroverter Chopper meets the high reliability standards required.

Send for complete details. More than 200 variations are available.

Bristol Syncroverter Chopper (in hand) and 1000-watt power amplifier unit, cover removed.

The Bristol Company, Aircraft Equipment Division, 181 Bristol Road, Waterbury 20, Conn.
A Subsidiary of American Chain & Cable Company, Inc.

ACCO

1.6 *T. M. Reg. U. S. Pat. Off.

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

CIRCLE NO. 29 ON INQUIRY CARD

TESTING

Size Gauge For O-rings

Parker Seal Co., Culver City, Calif. has developed a visual O-Ring Size Gauge which enables O-Ring users to check I. D. and cross section of O-Rings without manual or mechanical measuring. The gauge consists of a single unit cone and base with adjustable cross section measuring strip. The cone is counted on a slotted base. The I. D. of the O-Ring is measured by placing the O-Ring on the cone, while the cross section is measured with slots in the base. Proper relationship of Parker Seal -2 Series or ARP (AN) sizes can be checked by reading vertical column on the adjustable strip. List price is $3.50.

Write No. 731 in Box on Inquiry Card

Reference Voltage Source

When used with null seeking galvanometer type indicating controllers, new reference voltage sources provide an extreme measuring sensitivity for processes which incorporate minimum time lags compatible to 5% or less proportioning band. Three-digit dial provides minute (one degree) adjustment of set point. Null balance circuitry eliminates the effect of leadwire length on calibration. Unit incorporates a Zener diode stabilized source; adding resistances provides a choice of response times. Cold junction compensation is continuous and over-all measurement sensitivity is 0.25°F and is better with base-metal thermocouples. Wheelco Ind. Instr. Div., Barber-Colman Co., Rockford, Ill.

Write No. 728 in Box on Inquiry Card

Voltage-Current Calibrator

Sensitivity down to 1 mv, over 100 Mc input signal bandwidth, 0.1" FS output accuracy, and maximum operating stability (through the use of cascaded zener diodes) characterize comparator type, signal measuring instruments that sample and measure ac pulse or dc signal from 1 mv to 10 v; to 200 with signal attenuator. Units supply positive or negative reference voltage signals, which pass through a 400 cycle, low noise chopper and are displayed on a standard external oscilloscope. To measure the unknown signal, the reference voltage is changed until the line generated on the scope coincides with unknown peak, the value is then being read directly from a precision potentiometer. Rese Engineering, Inc., Philadelphia, Pa.

Write No. 753 in Box on Inquiry Card

Dynamic Rectifier Tester

For separate forward and reverse testing of semiconductor diodes, a new test instrument is used with X-Y oscilloscope for displaying the current-voltage characteristic. Forward and reverse voltages are independently adjustable. For measurement of reverse leakage, 0.5% precision resistors are used and a calibrated resistor is used for measurement of forward current. In the forward test, current is adjustable from 0 to 100 amps peak. In the reverse test, voltage can be varied from 0 to 2000 volts peak. Instrument Development Corp., Pittsburgh, Pa.

Write No. 740 in Box on Inquiry Card

Resolver Function Bridge

Deviation of a computing resolver's output to the ideal is measured with a resolver function bridge. The difference is expressed as a percentage and is directly displayed upon a panel meter. Meeting MIL-S-22666, the device will not introduce more than 0.002% error into the test. Internal phase-sensitive detection circuits respond only to the fundamental in-phase component of resolver output. Theta Instrument Corp., Saddle Brook, N. J.

Write No. 730 in Box on Inquiry Card

Null Indicators

Designated MM-1 (Medalist) and MCE-1 (edgewise), two meters employ core magnet, self-shielded mechanisms in unique structures providing high sensitivity at the null point and sharp square-law attenuation as the pointers deflect from center. The meters can indicate large amounts of unbalance in bridge or other detection circuits without damage to the instruments. Sensitivities of one-half, one and two microamps at the null point, with end scale values of 100, 200 and 500 microamps are available. Minneapolis Honeywell Reg. Co., Manchester, N.H.

Write No. 735 in Box on Inquiry Card

Hi-Speed Thin Film Tester

Programmable pulse generators capable of rapid analysis, testing and programming of thin film and cryogenic devices, also find application in the testing of magnetic toroid and transfluxor memories, as well as in the testing and evaluation of digital and analog circuitry. The unit is capable of running at a clock frequency higher than 4 megacycles, at levels having 25 nanosecond rise times and 50 nanosecond widths. It will deliver four separate trains of both logical levels and pulses. Digital Equip. Corp., Maynard, Mass.

Write No. 734 in Box on Inquiry Card

The ultra-reliable
dry circuit contact available today!

Tecknit Fuzz Buttons, a new concept in high-reliability contact design, are made of knitted wire mesh compressed into a resilient form.

These Fuzz Buttons make reliable contact under dry circuit conditions. They are made of wire having a contact radius of .0005" to .0015", resulting in a pressure high enough to break through non-conducting films with a relatively small total force. Additional reliability is gained from the redundancy of contact made to the same wire in at least four or more places.

For anti-bounce characteristics, Fuzz Buttons have a built-in mechanical hysteresis. Impact energy is absorbed by internal friction and softened by the non-linearity of compression. This makes Fuzz Buttons ideally suited for relays, switches, choppers and similar devices where contact bounce is a difficult problem.

For a free sample and technical literature from Tecknit Design Service, mail the coupon below — today!

TECKNIT®
Technical Wire Products, Inc.
48 Brown Avenue, Springfield, N. J.
PHONE: Area Code 201—DRexel 6-3010
TWX: MLBN 40
PJ-360

Technical Wire Products, Inc. EM-661
48 Brown Avenue, Springfield, N. J.
Please send me
Fuzz Button samples and literature.
NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

CIRCLE NO. 30 ON INQUIRY CARD

INLAND d-c torque motors save critical weight in guidance systems

PLATFORM SHOWN ½ SIZE

Norden Miniature All-Attitude Inertial Platform uses four Inland torque motors, one for each gimbal axis.

Norden specifies these Inland d-c torque motors because of their compact pancake shape, low-power input and direct torquing. In addition to providing the obvious weight and space reduction, Inland's direct drive positioning eliminates gear train problems such as backlash.

Norden engineers say, "The linearity of the Inland torquers is excellent over a wide range so that precession rates may be accurately established. The torquer fixed field is carefully stabilized so that the torquer gradients will be constant over long periods of time."

Inland d-c pancake torque motors with high torque-to-inertia ratios and linearity of output provide all the advantages of direct gearless servo positioning in a complete line over the full range of 0.1 to 3,000 pound-feet.

COMPARE THESE TYPICAL INLAND TORQUER RATINGS

	T-1321-A	T-2136-A	T-2108-B
Peak torque, oz. in.	20.0	35.0	60.0
Volts at peak torque, stalled at 250°C	48.0	26.0	25.6
Amps at peak torque	1.21	1.6	1.24
Total friction, oz. in.	0.5	0.8	1.5
Rotor Inertia, oz. in sec^2	.001	.007	.011
Weight, oz.	5.0	9.0	14.0
Dimensions (inches):—O.D.	1.937	2.81	2.81
I.D.	.625	1.00	1.00
Thickness	.50	.63	1.00

For complete catalog with engineering data, outline drawings and specifications on these and other Inland d-c pancake torquers, write Inland Motor Corporation of Virginia, Northampton, Massachusetts. Dept. 4-6

INLAND MOTOR CORPORATION OF VIRGINIA
A SUBSIDIARY OF KOLLMORGEN CORPORATION
NORTHAMPTON, MASS.

CIRCLE NO. 31 ON INQUIRY CARD

G-Accelerator

Electronically speed-controlled centrifuge can be used for research and development applications, product reliability tests, checkout of commercial guidance packages and production component evaluation. Order of precision of the Model 931 G-accelerator is indicated by a 0.001% allowable drift from angular velocity of either the main rotating arm or the outboard table. Crystal-controlled oscillator that determines overall setting accuracy accounts for this precision. The G-accelerator may be set up to maintain a spatially stable platform for the test object or to create several discrete and very accurate sinusoidal or constant g-accelerations. Operating modes include fixed azimuth orientation. Genisco, Inc., Los Angles, Calif.

Write No. 738 in Box on Inquiry Card

Direct Readout Signal Generator

A 406 to 549.5 megacycle signal generator displays generated frequencies in 5 digit direct readout form. The self-contained UHF test generator and power supply features continuous tuning across the frequency band, generating continuous wave or FM signals. Accurate to ±0.005%, the RF output signal can be modulated to ±300 Kc. by externally generated audio signals within the 300 to 100,000 cps range. Output power is variable over the range of 1.0 to 100,000 microvolts. Power requirements are 625 watts max., 115 vac ±10%. Babcock Electronics Corp., Costa Mesa, Calif.

Write No. 733 in Box on Inquiry Card

Two Channel Recorder

Oscillographic recording system, which uses plug-in interchangeable preamplifiers, permits easy movement between rooms or into and out of elevators. It has low impedance, enclosed galvanometers, and uses heated stylus method to produce immediately visible traces on 50 mm rectangular coordinate charts moving at one of 4 pushbutton-selected speeds. Frequency response: to 125 cps, within 3 db at 10 mm peak-to-peak amplitude; gain stability: better than 1% over 20°C temperature changes and 20 volt power line variations; max nonlinearity: 0.25 mm. Sanborn Co., Waltham, Mass.

Write No. 736 in Box on Inquiry Card

If you're headed for a product requiring magnets ...consider Ceramagnet®

The road leading to a new product may be filled with detours where conventional magnets are concerned. That's where Stackpole Ceramagnet permanent magnets warrant prompt and serious consideration. By providing important characteristics, to extents unobtainable in metallic units, they pave the way to many new and unusual design and engineering approaches.

Ceramagnet's high coercive force permits use without keepers or pole pieces, with many poles on a single flat face, and under other conditions which would quickly demagnetize ordinary units. Moreover, Ceramagnet is chemically inert, electrically nonconductive. Molded from ceramic powders, Ceramagnet permanent magnets can readily be produced economically to practically any size or shape.

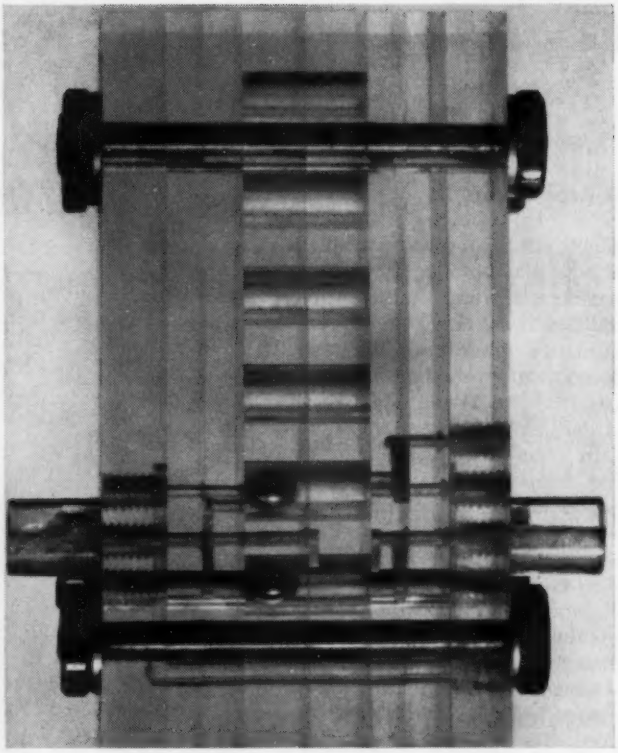
For ideas and technical data, write for Ceramagnet Bulletin, Stackpole Carbon Company, St. Marys, Pa.

STACKPOLE Ceramagnet®

GRAPHITE BEARINGS & SEAL RINGS • ELECTRICAL CONTACTS • ROCKET NOZZLES • VOLTAGE REGULATOR DISCS • PUMP VANES • CHEMICAL ANODES • CERAMIC MAGNETS • WELDING & BRAZING TIPS • FERRITE CORES • FIXED & VARIABLE COMPOSITION RESISTORS • SLIDE & SNAP SWITCHES • AND MANY OTHER CARBON, GRAPHITE AND ELECTRONIC PRODUCTS

CIRCLE NO. 32 ON INQUIRY CARD

RESEARCH



Enlarged view of Laboratory prototype contains two bistable elements, or flip-flops, and capacity for four more. "Piping", nothing more than holes drilled in the various layers, can be seen clearly. Connections to elements are made through screw holes at either side, and stages are created by removing the cover plates and clamping elements together.

PNEUMATIC DIGITAL COMPUTER

Gas Powered Flip-Flops With Packaging Density of 6000 per Cubic Inch Provide Electrical-Pneumatic Signal Conversion

Pneumatically operated devices have generally been considered inherently bulky, slow in operation, and useful primarily where the output is a relatively large amount of mechanical work. Kearfott engineers under the direction of Hugh E. Riordan have found, however, that by accepting only the limitations imposed by physical laws and current fabrication technology they can build compact pneumatic devices with response times comparable to those of many electronic and electrical components.

Among the more promising pneumatic devices being investigated at Kearfott is a fully pneumatic digital computer. The investigators predict this computer will be able to do everything an electronic or mechanical computer can do, but will be smaller, cheaper, more reliable and easier to service and test. Equally important, they say, is that it will be able to operate in temperatures from −100°F to +2000°F without provision for heating or cooling, and in virtually any radiation environment since it will have no solid state or other electronic components. The device that makes this computer possible is a Kearfott bistable element, or flip-flop, that operates on compressed air or other gas, and has a switching time of ten millionths of a second. The element can be packaged at 6000/cubic inch, or about 3000/cubic inch with all interconnections. Thus, they estimate, a medium size, general purpose, pneumatic digital computer, complete with memory, will occupy a volume measuring only about 5½ x 5½ x 1 inches, Table I lists the advantages of a pneumatic computer, as summarized by Kearfott.

TABLE I

PNEUMATIC COMPUTER ADVANTAGES

Inherent advantages of a pneumatic computer are:

- **Broad operating temperature range, limited only by the structural integrity of the materials of fabrication**
- **Immunity to ionizing radiation**
- **Simplicity of power supply**
- **Ease of information insertion using punched tape or cards, or direct mechanical transducers**
- **No heat dissipation by computer elements, thus permitting dense packaging.**

Further advantages which may be obtained by an intelligent selection of operating principles and constructions are:

- **High reliability**
- **Extremely small size**
- **Easy conversion between pneumatic and electrical signals**
- **Easy amplication of output to power levels which can perform useful mechanical work**
- **Manufacture using existing mechanical machining and fabrication techniques**
- **Relatively low cost**
- **If the elements used in the pneumatic circuits are properly designed, there can be no risk of permanent damage caused by poor power supply regulation, temporary open or short circuits, or overloads on the output.**

A digital approach to the pneumatic computer was selected for the same reasons as for an electronic computer, and for two additional reasons. The first is the inherent non-linearity of pneumatic instrumentation, and the second is the fact that close control of supply pressure and temperature is ordinarily necessary in pneumatic instrumentation. Since digital circuitry is dependent only on signal timing and duration, and not on magnitude, the effects of non-linearities and non-precise power supply regulation pose no problems.

PNEUMATIC COMPUTER ELEMENTS

The computer is based upon the pneumatic instrumentation of the diode and the bistable amplifier; resistance, inductance and capacitance; and use of the principles of the

acoustic transmission line.

In pneumatic circuitry, a diode is merely an orifice operating above critical flow, that is, with gas flowing through the throat at or above the speed of sound. For such flow conditions, a pressure disturbance originating upstream of the orifice will propagate downstream through the orifice. On the other hand, a disturbance originating downstream cannot propagate upstream past the orifice since the speed of pressure propagation is the speed of sound and the downstream flow through the orifice is greater than the speed of sound. The ratio of supply to discharge pressure across an orifice for critical flow is roughly two to one for most gases. Thus, extensive cascading of critical-flow orifices will require very high supply pressures unless buffer amplifiers are used.

Since a pneumatic resistance is an orifice or capillary, the instrumentation of simple diode logic circuits involves merely the appropriate interconnection of orifices and capillaries of various sizes.

The pneumatic capacitance is a plenum chamber, and the inductance is a "long" pipe of sufficiently large diameter that viscous losses do not predominate. The differential equations of pneumatic transmission and delay lines are similar to those of rf waveguides; detailed treatments can be found in the literature of acoustics.

Unlike some other approaches (e.g., Diamond Ordnance Fuze Laboratory and the Russian) to the pneumatic bistable amplifier, the Kearfott device utilizes a moving part. The important advantage of this feature is that it provides a direct means of converting between electrical and pneumatic signals, thus eliminating the need for additional volume or complexity to accomplish this in the pneumatic computer. That the presence of the moving part is no environmental hazard can be appreciated from the fact that a shock of over fifty thousand g's would be required to disturb a typical Kearfott bistable element operating on 100 psi differential pressure.

Conversion from pneumatic to electrical signals is effected by sensing the position of the moving part by means of a coil, or by capacitor plates or contacts embedded in the walls of the cylinder of the bistable element. Conversion from electrical to pneumatic data is accomplished by forcing shuttle motion magnetically or electrostatically.

A diagrammatic representation of a bistable element using a ball-shaped shuttle is shown in Figure 1. The basic element consists of a ball moving freely, but not loosely, in a cylindrical housing having four tubular connections. The various connections are numbered from one through four, and the two stable positions of the ball are designated by *A* and *B*.

This device can be operated in a number of different ways. One of the simple connections is shown in Fig. 2. The two axial connections, *1* and *2*, are supplied through separate flow restricting orifices by a common pneumatic supply at a pressure P_s. The radial connections, *3* and *4*, are open to the atmosphere. The ball is initially at position *A*.

Under these conditions, inlet *1* is

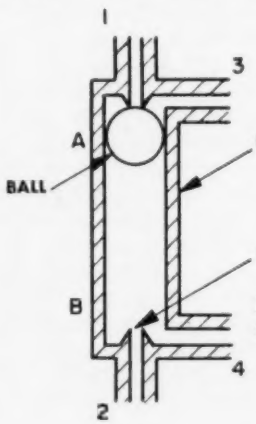
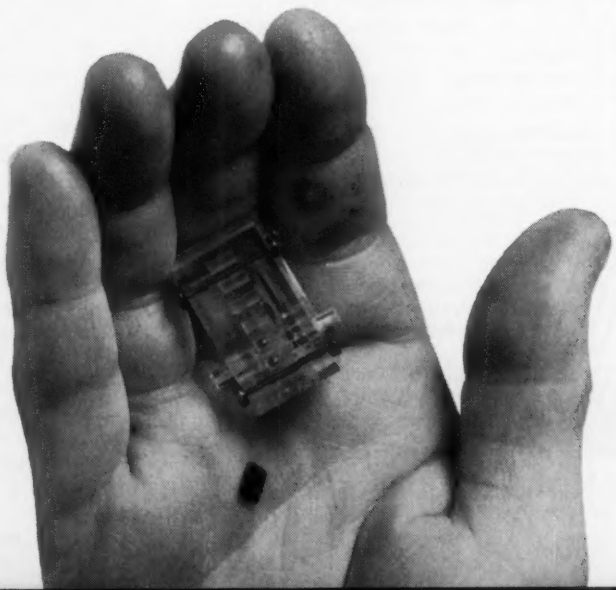


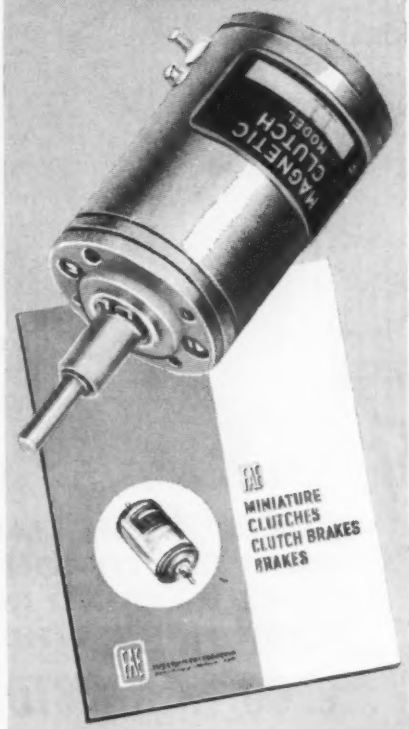
Fig 1 Basic bistable element.



Tiny black box performs the same functions as the transparent laboratory model of a pneumatic computer module i.e., six flip-flops. Designers expect to reduce the size of the module even more. Elements can be packaged to a density of 2,000 to 4,000/cubic inch.

precision-engineered miniature magnetic

CLUTCHES CLUTCH-BRAKES BRAKES



write for new catalog!

For guaranteed high performance and utmost reliability investigate FAE Miniature Magnetic Clutches, Clutch-Brakes and Brakes. Available in Sizes 8, 11 and 18 (in single or double-end Direct-Action, independent Direct-Action, Reverse-Action and Duplex-Action types) with choice of friction or crown-tooth coupling faces and modifications, as required.

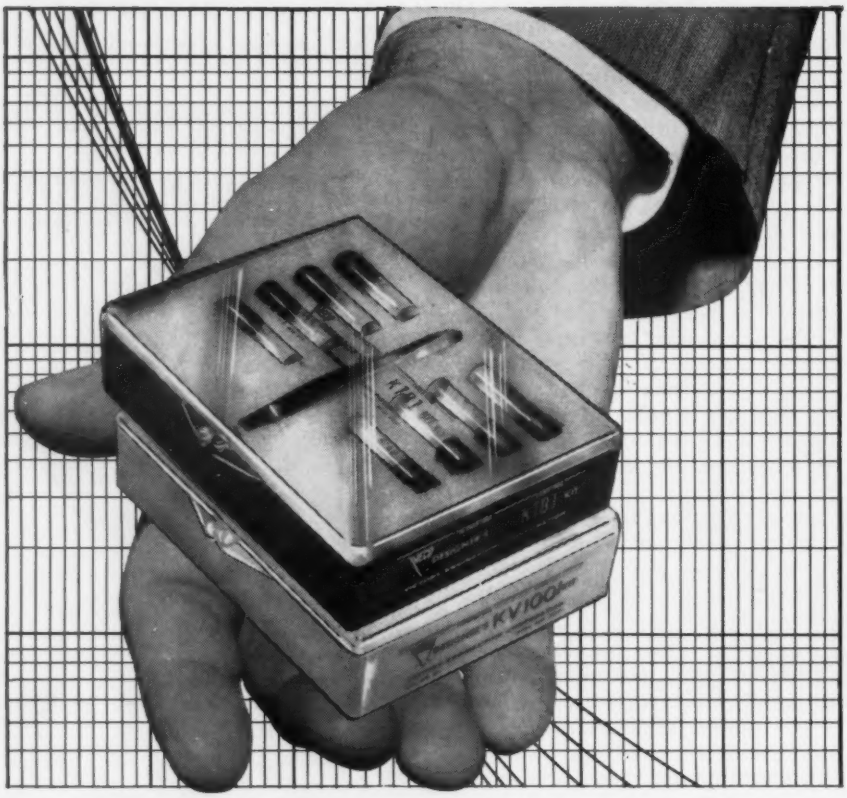
APPLICATIONS: Servo systems, computers, antenna drives and other critical commercial or military uses. WRITE TODAY FOR COMPLETE DATA.

FAE

INSTRUMENT CORP.
15 NORDEN LANE
HUNTINGTON STA., N. Y.
516-AR 1-0300

OTHER FAE ROTATING COMPONENTS: GEAR HEADS • GEARS • SPEED REDUCERS • DIFFERENTIALS • BELLOWS COUPLINGS • BALANCED CLAMPS

CIRCLE NO. 45 ON INQUIRY CARD



THE MOST RELIABLE SOLUTION TO MANY ELECTRONIC PROBLEMS CAN BE FOUND IN THE PALM OF YOUR HAND WHEN YOU USE...

VECO THERMISTORS AND VARISTORS

What better way to prove to yourself the reliability of VECO **Thermistors** and **Varistors** than by testing them under the actual environmental conditions in which they are to be used? VECO Thermistor and Varistor Circuit Design Kits give you the opportunity of doing this to your complete satisfaction. In kit form they cost so much less — and each kit presents a full range of resistance values of the various bead, disc, rod, and washer type Thermistors or a wide assortment of standard Varistors. Here's your opportunity to put stock Thermistors and Varistors through your toughest quality control tests. Once you've tried them you'll agree —VECO is the leader in reliability.

KD 25	Thermistor Disc Kit—13 VECO Discs	$12.50
KP 50	Thermistor Glass Probe Kit—6 VECO Probes	14.50
KR 75	Thermistor Rod Kit—8 VECO Rods	9.50
KTB1	Thermistor Bead Kit—8 VECO Beads	19.50
KW125	Thermistor Washer Kit—12 VECO Washers	13.50
KV100	Varistor Kit—8 VECO Varistors (assorted types)	14.50
KV1001	Varistor Kit—9 VECO Varistor Discs	7.50

ABOVE ITEMS SENT PARCEL POST POSTPAID

Other VECO Products:
Thermistors • Varistors

Chopperettes • Combustion Analyzers • Thermistors, Catheters and Needles • Matched Thermistors • Thermal Conductivity Cells Hypsometers • LOX Thermistors — any many others.

VECO glass enclosed thermistors are not adversely affected by radiation. Our quality control processes are accepted under MIL-Q-5923 standards.

FREE:
To learn more about VECO Circuit Design Kits write for folder SE102

Cataloged in EEM and Radio Master

VECO VICTORY ENGINEERING CORPORATION

120 SPRINGFIELD ROAD, UNION, N. J. • MUrdock 8-7150

CIRCLE NO. 77 ON INQUIRY CARD

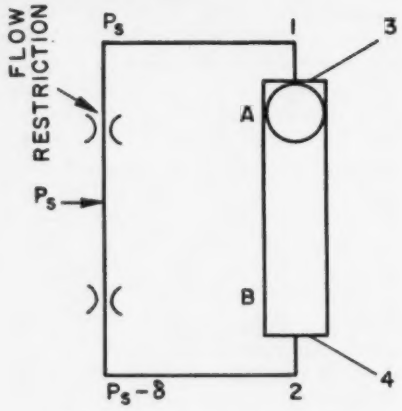


Fig 2 Simple bi-stable circuit

closed by the ball, hence no flow occurs through its supply orifice and the pressure at *1* is equal to the supply pressure. Flow is present, however, through the supply orifice for inlet *2*, in through the seat at *2*, out through *4*. Since the ball does not provide a leaktight fit in the cylinder, a small flow passes around the ball and out through *3*. Because of the flow through orifice *2*, there is a pressure drop δ across the orifice, and the pressure at *2* is $P_s - \delta$.

Forces on the ball are the resultant of: (1) P_s acting on the area of the seat opening and tending to force the ball away from *A*, (2) the pressure in the cylinder acting on the entire ball area, urging the ball toward *A*, and (3) a very small pressure on the ball area less the seat area due to the back pressure at *3*, tending to force the ball away from *A*. Given the proper built-in flow restriction in the side connections, and proper choice of seat diameter relative to ball diameter, the force due to the pressure in the cylinder will tend to keep the ball at *A* as long as both side connections, *3* and *4*, are open.

If *3* is closed, pressure in the cylinder on both sides of the ball will equalize because of leakage between the ball and cylinder wall. There will remain the force acting on the seat area which will move the ball away from *A*. As soon as the seal between the ball and seat *A* is broken, the supply pressure acts on the entire ball area, and the ball is driven rapidly to *B*. If the connection at *3* is now reopened, the ball will be found to remain at *B* under conditions of equilibrium similar to those which obtained initially at position *A*, except that there will now be a relatively large flow out of *3*, a small flow out of *4*, supply pressure at *2*, and pressure $P_s - \delta$ at *1*. Thus the momentary

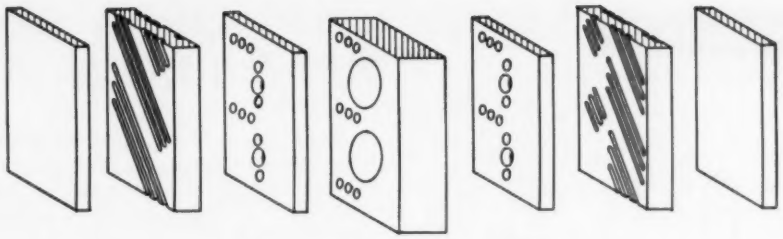


Fig 3 Computer module construction

closure of 3 has caused the device to reverse its pressure and flow states. A momentary closure of 4 will cause the ball to return to A and remain there. The device therefore exhibits the properties of a true bistable element.

Since a pressure pulse applied at a radial connection of the bistable element has the same effect in inhibiting outward flow as a closure, the device can also be operated as a pulse-responsive device. In the case of pressure rather than closure input, the actuation time of the element will be reduced, since dependence is no longer placed entirely on leakage past the ball to bring the unit to the trigger point.

The output of the device can be taken as the pressure drop across the supply orifices; the orifices in this case are analogous to the load resistors in a vacuum tube circuit.

Gain of a bistable stage is, of course, undefined for a closure input; however the pressure gain for a pressure input can be defined as the ratio of the drop across the supply orifice to the magnitude of the input pressure. This ratio is controlled by the pressure differential across the ball in one of the stable states, since the input pressure must be large enough to overcome the pressure differential which holds the ball on the seat. This pressure differential and hence the gain may be controlled by providing flow restrictions in the radial branches 3 and 4 (Fig 2). Pressure gains as high as 100 for a single stage appear to be entirely feasible.

TOLERANCE REQUIREMENTS

The bistable element operates in terms of pressure differentials, and does not, therefore, require overly accurate control of supply pressure, temperature, and leakage within the unit. No absolute seals are required. It is only necessary that certain inequalities in leakage areas have the right sense and approximate magnitude. Typical tolerances and critical dimensions might be: Cylinder diameter: 0.020 ±0.0005 in. Moving element diameter: 0.019 ±0.0002 in. Port and orifice dia.: 0.010 to 0.004 ±0.0002 in.

These tolerances and sizes are all within the capabilities of equipment and techniques presently in use at Kearfott and elsewhere.

CONSTRUCTION AND PACKAGING

To provide the maximum packaging density and acceptable design flexibility, the computer circuits and elements are assembled from layers of perforated plates which form the elements themselves and also furnish the means of interconnection. This technique permits standardization of the majority of the computer parts and requires only the completion of a limited number of simple secondary operations to effect the desired circuit connections.

As can be seen from the exploded view of a portion of a module shown in Fig 3, the basic construction consists of a stack of five perforated and two solid plates. The second plates from the outside are matrix plates, which contain herringbone patterns of grooves in their two faces. The circuit connections are made simply by drilling through the matrix plates at the appropriate intersections of grooves.

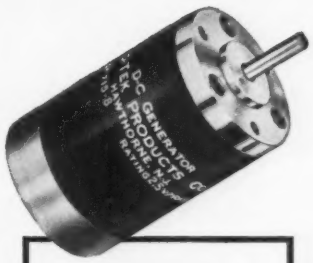
For moderate operating temperatures, the matrix plates can be made of any material capable of being fabricated by photoetching or chemical milling. High temperature operation can be provided by using ceramics or high temperature alloys. These materials can now be fabricated with little or no trouble by etching, electroerosion or ultrasonic machining.

Use of the matrix plate method of construction permits very high packaging densities with existing fabrication techniques. Typical packaging densities, including power supply and interconnecting circuitry are 2,000 to 4,000 bistable elements per cu. in.

With such packaging densities a complete medium size general purpose digital computer complete with matrix type memory will occupy a slab approximately 5½ inches square and one inch thick.

Applications of the Kearfott bistable element to some typical logic circuits is illustrated in Figs 4, 5 and 6. In each case the input is assumed to be a pulse and the output is the pressure

NEW!



direct-current
TACHOMETER GENERATOR
permanent-magnet

APPLICATIONS

SERVOS The highly linear output and wide speed range are ideal for velocity or integrating servos. Low driving torque permits its use as a damping or rate signal in all types of servos.

INDICATING TACHOMETER Matching indicating meters available from stock in various speed ranges.

SPEED TRANSDUCER Ideal for use as a speed transducer in connection with fast-response direct-writing oscillographs.

FEATURES

SIZE Miniature. Approx. Dia 1⅛"

OUTPUT Various models with outputs as high as 45 v/1000 rpm.

LINEARITY Linearity from 0 to 12,000 rpm is better than 1/10 of 1% of voltage output at 3600 rpm.

BRUSH LIFE Better than 100,000 hours (10 years) of continuous operation at 3600 rpm.

BIDIRECTIONAL OPERATION Output in either direction is held to a ¼ of 1% tolerance.

RIPPLE The rms value will not exceed 3% of the d-c value at any speed in excess of 100 rpm.

CONSTRUCTION Aluminum housings with protective treatment; stainless steel shafts; fully shielded ball bearings; Mylar insulation.

SINGLE UNITS FROM $24.50
quantity discounts

Our Engineering Test Report describing performance characteristics, test procedures and test results, is available at no charge, upon request.

SEND FOR COMPLETE DATA

Servo-Tek PRODUCTS CO.

Main Office: 1086 Goffle Road, Hawthorne, N. J.
Western Office: 14736 Arminta St. Van Nuys, Cal.

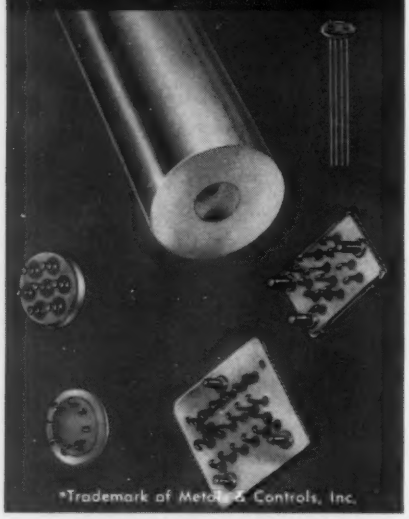
CIRCLE NO. 34 ON INQUIRY CARD

Get Optimum

- thermal conductivity
- electrical conductivity
- sealing ability
- expansion compatibility
- processing qualities

in one

MULtiLAYER* clad wire

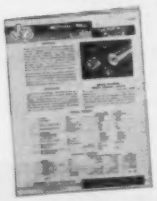


*Trademark of Metals & Controls, Inc.

#446 STAINLESS CLAD COPPER GLASS SEALING WIRE

Through the material matching magic of MULtiLAYER clad metals you can now have a glass sealing wire which has a copper core for conductivity and a stainless steel jacket for thermal expansion properties approximating that of glass. This means a perfect combination for glass-to-metal seal material for terminals, hermetic seal headers, switches, relays, coils, capacitors, rectifiers, transformers, potentiometers, etc.

The clad bond between the oxygen free high conductivity copper and the #446 stainless steel is an absolutely sound, metallurgical bond with no interliner, solder, or brazing alloy — continuous, complete, and gas tight.



WRITE or call Marketing Manager, Clad Wire department for FREE LITERATURE which gives physical and mechanical properties of this wire and other specifications such as co-efficients of expansion, temper, forms and sizes, and weights.

METALS & CONTROLS INC.,
8206 Forest Street, Attleboro, Mass.
A CORPORATE DIVISION OF
TEXAS INSTRUMENTS INCORPORATED

CIRCLE NO. 80 ON INQUIRY CARD

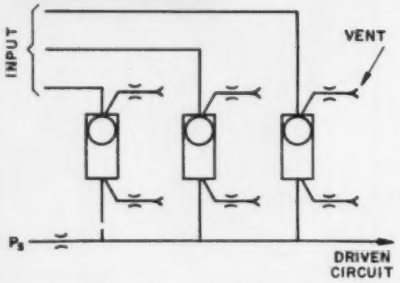


Fig 4 Active "and" buffer

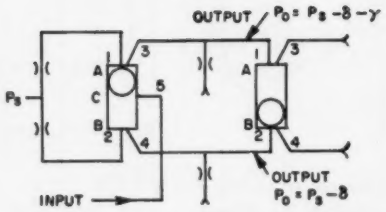


Fig 5b During signal pulse

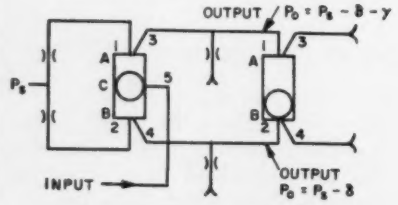


Fig 5a Before signal pulse

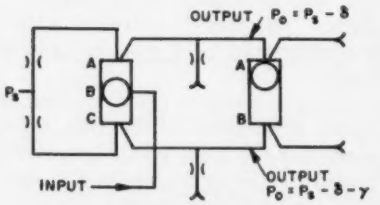


Fig 5c After signal pulse

Fig 5 Single-input binary flip-flop

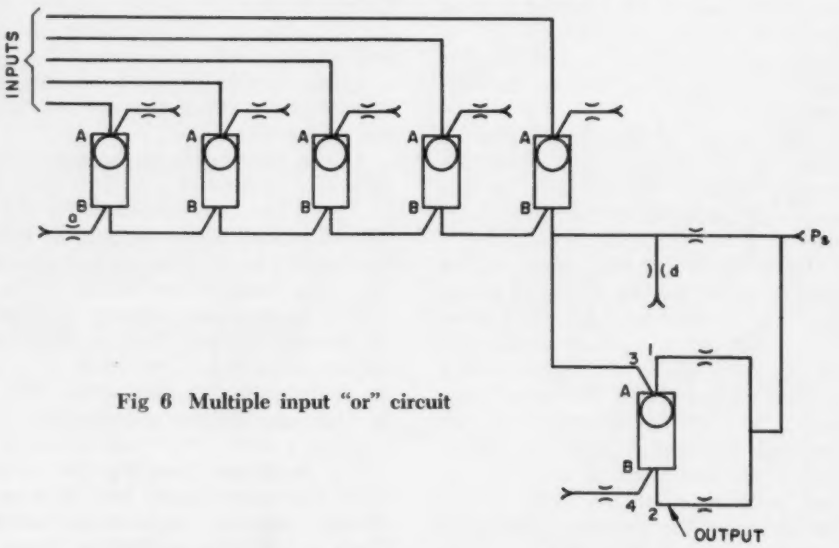


Fig 6 Multiple input "or" circuit

rise at the indicated location. As with electrical circuits, appropriate measures must be taken to satisfy impedance matching and loading requirements. Buffering, oscillator, and isolation circuits have been designed for use in interconnecting circuits.

The circuit for the binary scaler (Fig 5) is of special interest since it uses a tristable as well as bistable element. The input is to a tristable element, which is formed by adding another connection at the center of the cylinder of a normal bistable element. When this center connection is open, the ball is driven to the center of the cylinder and remains there regardless of conditions at outlets 3 and 4. When the center outlet is closed, the element behaves as a bistable device.

The two diagrams of Fig 5 show the states of the output element before and after application of a pulse to the input. Each time a pulse is applied to the input, the output element reverses its state.

Although relatively slow compared with faster electronic computers, the Kearfott pneumatic computer, with clock frequencies in the range between 10 and 100 kc, will be able to satisfy many relatively high speed computation requirements by taking advantage of lower cost and high packaging density which will permit employing parallel rather than serial computation.

Power comsumption for the pneumatic computer is comparable to that of an electronic computer of comparable capacity. The small size of the orifices and passages used will require cleanliness of the gas supply equivalent to that obtained with three micron filtering. • • •

Write No. 250 in Box on Inquiry Card

Now—A High-Performance Potentiometer For As Little As $3

NUMBER 15—NEW PRODUCT SERIES

Never before could you find a low price tag on this kind of potentiometer performance. Now—for as little as $3 a unit in quantity orders—you can buy a single-turn ½" wirewound rotary that meets the highest standards for computer and industrial control applications.

Weighing in at a scant .05 ounce, the ½" dia. Trimpot® Model 3367 dissipates 0.5 watt, operates in 105°C heat, and holds residual end-setting resistance from 0 to 1.0%. It meets requirements for steady-state humidity and Mil Specs for sand, dust, salt spray and fungus. Designed for convenience, too, it has index points that let you check your setting at a glance.

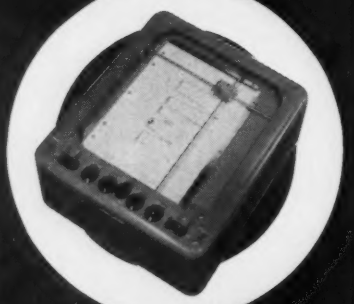
Reliability well beyond the expected is made possible by the exclusive Bourns Silverweld® termination. Alloyed with multiple turns of the resistance wire, Silverweld eliminates vulnerable single-wire terminations, is virtually indestructible under thermal or mechanical stress. Units are 100% inspected, and subjected to the rigid double-check of the Bourns Reliability Assurance Program.

Model 3367 is available immediately from factory and distributor stocks with resistances of 100Ω to 20K. Your choice of printed circuit pins (spaced for interchangeability with more expensive devices) or solder lugs with bushing mount. Write for complete data and list of stocking distributors.

Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure and acceleration.

CIRCLE NO. 37 ON INQUIRY CARD

XY [GRAPH] RECORDER



20

20 important features to consider

- ½% accuracy
- Standard 8½"x 11" graph paper
- Flat bed
- 7½ in/sec. pen speed
- Clip on pens for multicolor trace
- Unconditional one year warranty
- Drift free
- Continuously variable attenuators
- Each axis mechanically & electrically independent
- Critically damped response
- Rugged construction
- 120% zero offset
- Full chart visibility
- Floating inputs to 100 volts dc
- Interchangeable chopper stabilized amplifiers
- Inline simplified control panel
- 10 or 1 mv/in sensivity
- 10 k or potentiometric input
- Unobstructed paper loading
- Completely portable (35#—14" x 15" x 8")

CHECK LIST FOR ONLY $595

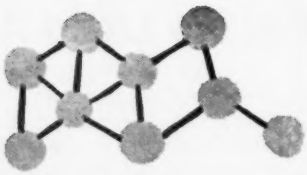
BONUS FEATURE
Immediate shipment within 48 hours.

Write today for BULLETIN 792-4 and PRICE LIST. All inquiries answered immediately.

houston instrument corporation
Box 22234 Houston 27, Texas
MO 7-7405

CIRCLE NO. 38 ON INQUIRY CARD

by David Bandel
Staff Columnist
Associate Technical Director,
TRACERLAB, INC.



MATERIALS

ISOTOPES IN NON-DESTRUCTIVE TESTING

It is interesting to observe how industry responds to innovation. Certain innovations are applied almost as soon as they are out of the laboratory while others appear to undergo a considerable induction period before they gain acceptance. There are, usually, fairly rational explanations for the variations in lag rate between innovation and application. Certain industries, particularly the older ones where a considerable body of art has been developed, are generally slow in accepting new ideas. Other industries of more recent origin, electronics for example, not only accept innovations eagerly, but spend a considerable sum generating new ideas, approaches and devices.

One powerful tool, radioisotopes, appears to have been seriously neglected by industry as a whole, with the one exception of the petroleum industry. Although radioisotopes have an almost unlimited range of capabilities in solving knotty problems, their application by American technology has been very spotty to date. Radioisotopes have been applied fairly intensively in certain limited areas, such as radiography, gaging and wear testing, where their advantages are readily apparent. Even in these applications only a fraction of the potential users have adapted radioisotopic devices and techniques, even where considerable field experience is already available.

Dr. Paul C. Aebersold, Director of the Office of Isotopes Development and Oscar M. Bizzell, Chief of the Isotope Technology Branch of the AEC have discussed the status of radioisotope development in a paper presented at the Western States Regional Convention of the Society for Non-destructive Testing held in Los Angeles. This paper summarizes the application of radioisotopes in non-destructive testing where radioisotopic techniques have made important contributions. The authors made the following observations.

"**It was a growing awareness** of the yet undeveloped potential of radioisotopes and radiation applications that led the Commission to establish a formal Isotopes Development Program. This program attempts to reduce the time lag between conception of a new principle and its practical application by generating a broad technological base for exploitation. In many industries, radioisotopes can be applied to non-destructive testing in a variety of ways — as tracers, in radiography, in gaging and in unique applications."

Several radioisotope techniques having applications of interest in the electronic and electromechanical field were described by Aebersold and Bizzell. Gamma reflectance methods have been studied that detect surface flaws without requiring access to the inner surface. Soft radiation from secondary x-ray sources can be used to radiograph low density materials (that is, encapsulated devices) for quality control of such components. Soft x-rays show fine detail and this technique has been used to produce radiographs of vacuum tube structures in completed units. Radiotracers are exceptionally valuable in investigating all aspects of fluid flow, including problems of detecting leaks, locating obstructions and measuring corrosion and erosion.

Aebersold and Bizzell concluded their paper with the following statement: "Development of new concepts should greatly broaden the already well established utility of radioisotopes. These versatile nuclear tools warrant considerable attention on the part of engineers, research directors and executives. Management in particular should be aware, not only of the widespread utility of isotopic non-destructive methods, but also of the profitability already demonstrated by numerous industrial applications."

A survey of the literature on radioisotopes shows that West Europeans and Russians have applied techniques aggressively to a variety of industrial problems ranging from blast furnaces to metal diffusion studies and special gaging instruments. One item of interest is a device for measuring concentricity of sheathed cables, described in Brit. Pat. 847,129. The sheathed cable is drawn through a block with a V shaped groove. A small radioisotope source, fixed at the apex, transmits radiation through the two paths. A differential intensity measuring system compares the radiation transmitted through the separate paths. Thus, deviations from concentricity are easily detected. • • •

These unique features show why Daystrom 341 Series Potentiometers have zero backlash and maximum resistance to shock and vibration.

Three things make these rotaries unique. (1) : our patented V-guide design which eliminates backlash. (2) : the use of our patented *double* wipers effectively doubles resolution. And (3) : impossible to see with the naked eye, is the winding; the resistive element is wound tightly in a precision groove cut into the mandrel by a tiny diamond tool. As a result, each turn always stays securely in position, despite severe shock and vibration.—■—Only Daystrom 341 Series rotaries offer these features. Available in values from 1K to 600K, rated at 2.5 watts in *still air*, they are only ½" in diameter and 1" long, with or without our patented clutch for servo use. They meet or exceed all applicable MIL specs.—■—Start solving your potentiometer problems now: contact your Daystrom Representative (or the factory) for more information on specifications, prices, fast delivery.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA

CIRCLE NO. 39 ON INQUIRY CARD

SILICON CONTROLLED SWITCHES . . . *from* SSPI

. . . Offering efficient switching in the 1-200 mA range and peak pulse current capability to 10 amperes, in the miniature TO-18 package.

Now in TO-18

- High sensitivity . . . 20 μA firing
- Close firing control . . . within ± .08V
- Voltage ratings to 200V
- MIL-S-19500 capability

Type	Maximum Anode Voltage (DC or Peak AC) ± Volts	Maximum Average Forward Current 75°C mA	Maximum Gate Current to "Fire" μA	Gate Voltage to Fire + Volts	
				Min.	Max.
2N884	15	200	20	.44	.60
2N885	30	200	20	.44	.60
2N886	60	200	20	.44	.60
2N887	100	200	20	.44	.60
2N888	150	200	20	.44	.60
2N889	200	200	20	.44	.60

Available for the first time in the miniature TO-18 case, these units offer the same high sensitivity and close characteristics control introduced by SSPI in pioneering PNPN devices for control and logic applications.

The precise firing characteristics of these devices make them ideal for timing and time delay circuits, voltage limit detectors, high gain static switching, logic circuits, and related applications.

With the high surge capability of this series, squib firing systems requiring pulse currents up to 5 amperes can be greatly miniaturized without sacrificing design margin. In addition, the low 1 mA holding current level is particularly useful in many programming, control and logic circuits.

Designed to meet the requirements of MIL-S-19500, these units are subjected to extensive temperature storage and cycling, as well as 100% acceptance testing, as a regular part of the manufacturing procedure.

Write for Bulletin C420-03.

CIRCLE NO. 40 ON INQUIRY CARD

PROVEN LEADERSHIP IN *PNPN* TECHNOLOGY . . . *from* SSPI

SOLID STATE *Products, Inc.*

ONE PINGREE STREET • SALEM, MASSACHUSETTS
PIONEER 5-2900

Are you on our mailing list for "New Design Ideas"?
FOR NAME ON MAILING LIST, CIRCLE NO. 78 ON INQUIRY CARD

COMPONENTS 21 DIGEST

SEMICONDUCTOR DEVICES Part III

This part of Components Digest 21 describes several important types of semiconductor devices whose behavior can be understood in terms of the theory presented in Part II published in April. The objective of this series is to provide the Electromechanical Engineer with an overall view of the variety of these devices so that he may be aware of their possible application in his design problems. Not all of the common types are covered in this issue, since additional theoretical background will have to be developed before the more complex devices can be described. Devices to be covered in this installment are listed in Table I.

THERMISTORS

Thermistors are resistors whose utility depends on the large negative temperature coefficient of resistance of semiconductors. They have the widest range of application and as a consequence many different varieties are available (see Table II).

Semiconductors include elements such as germanium, silicon, selenium, metallic oxides and sulfides. As explained in Part II of this series, the flow of current in a semiconductor may be described as a flow of negative electrons or positive holes. The positive hole is merely a vacancy which could be occupied by an electron, but it behaves for all practical purposes as if it were a positively charged particle with the charge magnitude, mass and mobility of an electron.

The thermistor characteristic of a semiconductor results from the effect of temperature on the electrons of the pure semiconductor material. As the temperature increases, more and more electrons in the valence energy band are induced to jump the energy gap to the conduction band leaving holes in the valence band. Thus, increasing the temperature of the semiconductor increases its conductivity (decreases its resistivity) by increasing the number of positive and negative current carriers. Impurity atoms in the semiconductor, which are instrumental in the performance of diodes and transistors, do not contribute to the desired negative temperature characteristic of thermistors, although many thermistors include impurities, primarily because of difficulties in removing them in manufacture.

Impurities in small percentages play a role at low temperatures where the electrons of the pure semiconductor have relatively little energy so that few occur in the conduction bands of the crystal. Most of the free carriers are then derived from impurity atoms. At higher temperatures the number of electrons of the *intrinsic* semiconductor to reach the conduction band increases, swamping out effects of impurities: Table III presents a simple quantitative expression relating the availability of conduction electrons and temperature.

Intrinsic Conduction in Semiconductors

Figure 1 shows how thermal energization leads to the presence of electrons in the conduction band of the semiconductor and holes in the valence band which had been previously filled. The holes in the valence band and the electrons in the conduction band exhibit a certain degree of mobility leading to current flow in the presence of an electric field. Figure 2 shows the resistivity of a number of practical thermistor materials, illustrating the large variation of intrinsic conductivity with temperature. The Figure presents the equations which describe the temperature dependence.

A great deal of the value of a thermistor lies in the stability of its properties with time. Thermistors are used in the compensation of precision transducers with overall accuracies of 0.1%, where precision must be maintained in severe environments over wide temperature ranges for thousands of hours. The principal factors

TABLE I • SEMICONDUCTOR DEVICES IN PART III

Thermistors

Temperature sensitive ohmic resistors which have a high negative temperature coefficient (NTC) and respond to either changes in ambient temperature or self heating. They are constructed in a variety of configurations and find wide application in temperature compensation, measurement, and control.

Voltage-sensitive Resistors

Bilateral (symmetrical) resistors which show no polarity preference; their electrical resistances depend on the instantaneous applied voltage much as does the forward (conducting) resistance of a rectifier. Unlike thermistors, they do not exhibit ohmic properties and an applied sinusoidal voltage will deliver a nonsinusoidal current. Effective resistance of the device decreases sharply with increasing voltage, leading to its application as a general purpose nonlinear element in particular circuits, as an arc or surge suppression device, and in a limited variety of voltage regulation, harmonic generation, and other circuits where its nonlinear properties can be utilized.

Zener Diodes

Germanium or silicon junction diodes whose inverse breakdown occurs abruptly as a result of an avalanche effect. At this breakdown, inverse current increases sharply with little change in voltage, making this device particularly suitable as a voltage reference. The breakdown voltage can be controlled in manufacture. Temperature compensated versions are available.

Point Contact Rectifiers

These rectifiers together with point contact transistors, are the original semiconductor devices developed at Bell Telephone Laboratories. Although they are little used today except in some communications and computer applications, they are considered here primarily because a knowledge of some aspects of their operation will be helpful in understanding other semiconductor devices. Their original advantage, suitability to high frequency applications, has been overcome by improvements in high frequency performance of some function types.

Bird
JEWEL BEARINGS
CUT YOUR COSTS
THROUGH UNIFORM QUALITY

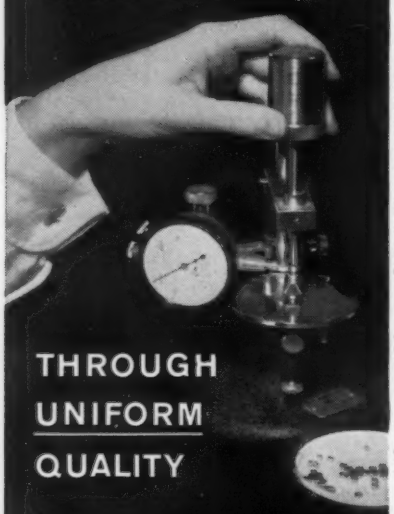


Illustration shows concentricity check of jewel assembly, just one of several important quality control steps.

Exacting quality control standards employed by Bird are your guarantee that every Bird Sapphire or Glass Jewel Bearing, or Complete Jewel Assembly or Cushion Jewel Assembly, is as specified. There's never a chance of inconsistency in dimensions, chemical and physical properties.

As an added benefit, Bird Complete Assemblies cut your manufacturing costs because they reach you ready for immediate installation . . . eliminating all problems with expensive rejects and breakage.

Our engineering staff would be pleased to work with you on your special jewel bearing needs. Write for our free catalog with complete details on properties and uses of jewel bearings.

Richard H. Bird & CO., INC.
1 SPRUCE ST., WALTHAM, MASS.
serving industry with fine jewels since 1913

CIRCLE NO. 79 ON INQUIRY CARD

COMPONENTS DIGEST

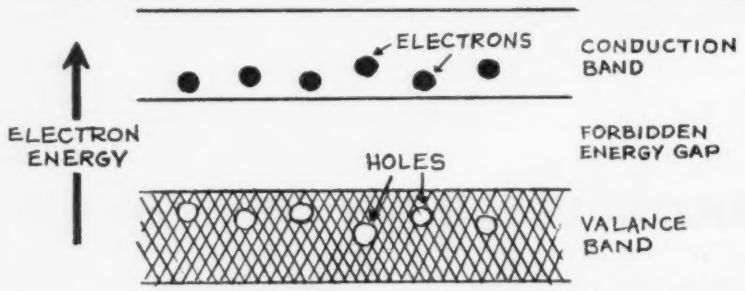


Fig 1 Thermal energizing leads to a concentration of electrons in the conduction band and holes in the valence band at all temperatures above absolute zero. The concentrations in an intrinsic semiconductor depend on temperature as shown in Table III.

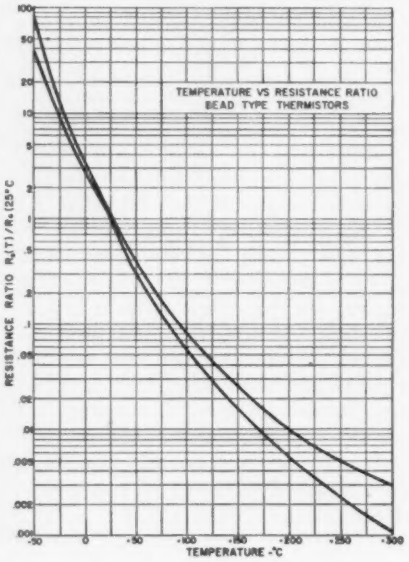


Fig 2A Resistance ratio versus temperature curves. Assume one-ohm resistance at 25°C. *Courtesy of Walter Kidde and Co. Inc.*

$R_t(T)/R_t(25°C)$

TEMP. °F	TEMP. °C	A	B	D	E	R
−76	−60	200.0	80.00	145.2	73.04	77.00
−58	−50	92.00	42.50	68.88	38.95	40.20
−40	−40	44.50	23.50	34.28	21.51	22.00
−22	−30	22.87	13.30	17.92	12.33	12.56
−4	−20	11.60	7.850	9.792	7.307	7.418
14	−10	6.300	4.700	5.560	4.476	4.540
32	0	3.550	2.900	3.274	2.825	2.850
50	10	2.090	1.850	1.992	1.830	1.840
68	20	1.270	1.220	1.250	1.216	1.220
77	25	1.000	1.000	1.000	1.000	1.000
86	30	.8000	.8270	.8053	.8267	.8250
104	40	.5130	.5660	.5316	.5742	.5700
122	50	.3450	.4010	.3595	.4067	.4020
140	60	.2310	.2860	.2482	.2937	.2890
158	70	.1620	.2110	.1747	.2160	.2120
176	80	.1140	.1560	.1252	.1615	.1570
194	90	.0816	.1170	.0912	.1229	.1190
212	100	.0600	.0900	.0675	.0946	.0910
230	110	.0454	.0695	.0507	.0739	.0705
248	120	.0343	.0550	.0386	.0584	.0552
266	130	.0264	.0428	.0298	.0470	.0437
284	140	.0208	.0341	.0232	.0382	.0350
302	150	.0165	.0272	.0184	.0313	.0285
320	160	.0132	.0222	.0147	.0259	
356	180	.0087	.0152	.0097	.0180	
392	200	.0058	.0106	.0066	.0130	
482	250	.0024	.0051			
572	300	.0011	.0030			

To use table, multiply resistance of thermistor at 25°C by factor from table to obtain resistance at specified temperature.

	A	B	D	E	R
β	4115±150	3495±175	3900±55°	3400±80	3450±80
α	−4.6%/°C	−3.9%/°C	−4.4%/°C	−3.9%/°C	−3.9%/°C

Fig 2B Resistance ratio versus temperature chart. Different characteristics relate to different thermistor materials. Mathematical expressions for resistance ratio and temperature coefficient versus temperature, and parameters for different materials. *Courtesy Walter Kidde and Co., Inc.*

$$R = R_0 e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

$$\alpha = \frac{1}{R_0}\frac{dR_0}{dT} \text{ or approximately } \frac{-\beta}{T^2}$$

Where β is the constant thermistor material; R_0 is the nominal resistance at reference temperature T_0 (°K); and R is the nominal resistance at temperature T (°K) β is determined from measurements at 0°C and 50°C

in achieving stability are the use of materials which do not change with use, are relatively insensitive to atmospheric influences at high temperatures, are sufficiently uniform in composition so that gradual internal "annealing" does not occur over the period of use, and which are thoroughly stable mechanically. Pre-aging at elevated temperatures is an important manufacturing process required to achieve small percentage variations over many years.

Because of the versatility of thermistors (note the variety listed in Table II) they are widely applied in such fields as temperature compensation, flow measurement, slow speed amplification and switching, measurement of radiant energy, time delay, etc. In many of these applications it is important to consider the effects of self-heating of the thermistor due to the current it is carrying, as well as the transient response of the thermistor to suddenly applied currents of amplitude sufficient to cause self-heating. Figures 3 through 5 show typical thermistor characteristics which are helpful in circuit design. Thermistor manufacturers provide ample data on design of temperature compensating thermistor circuits.

Table IV gives extensive hints on the selection and application of thermistors. Table V is a partial listing of thermistor manufacturers.

TABLE II • VARIETIES OF THERMISTORS

Bead Thermistors, Rods, Discs, Washers, Plates for Surface Mfg.

Different physical configurations for application to specific problems. Range of resistance values, temperature coefficients, lead configurations, mounting hardware, and wattage ratings are available. Wattage ratings of course depend a great deal on mounting on a heat sink.

Separate Heater Construction

In many applications it is desired to apply heat through a separate heater to the thermistor for external isolated control.

Probes

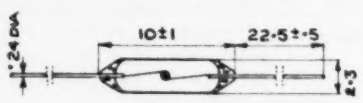
In many applications the thermistor is used to "sense" physical quantities such as flow rate, infrared radiation, gaseous pressures, etc. In such instances thermistors may be included in specially designed probes. Gulton Industries Inc. has devised a variety of these. Standard temperature probes measure as low as −300°F and as high as +700 F.

Construction of Bead Types
(as described by Mullard Ltd., of London.)

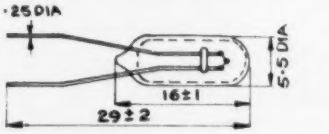
The beads consist of a mixture of metallic oxides fused on to platinum alloy connecting wires. The material is shrunk on to the wires by a sintering process, then covered with a thin layer of protective vitreous enamel.

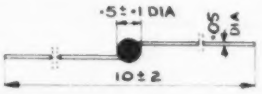
Where the bead is mounted in a glass container, tinned nickel-iron connecting wires are welded to the mounting wires and brought out through a glass pinch.

Types of Mounting (all dimensions in mm).

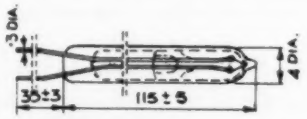


The platinum mounting wires are welded to the connecting wires which are of 34 S.W.G. tinned nickel-iron (0.24 mm in diameter). The bead and mounting wires are enclosed in a gas-filled glass bulb. These are supplied coated with vitreous enamel and provided with platinum-alloy connecting leads.

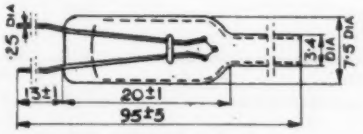




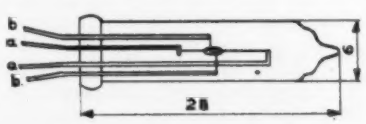
Very high sensitivity to current variations is achieved by this version which is mounted in an evacuated glass tube. This produces a lower dissipation constant of the order of 0.1 mW/°C but at the expense of a longer recovery time.



To facilitate a quick response to changes in ambient temperature at a given spot, the bead is embedded in the point of a glass envelope.



These are specially mounted in an open-ended glass envelope for the purposes of vacuum measurement. The open end is sealed to the vessel whose vacuum is being measured.



Both the bead and a separate heating element are fused into a glass mounting, the whole being enclosed in an evacuated glass envelope. The thermistor characteristics then become a function of the heater current, which can be controlled by a separate circuit.

TABLE III

BASIC THERMISTOR FORMULAS

(Some solid state theory, applied without proof to thermistors)

According to basic solid state theory, a pure semiconductor has a filled valence band separated from a conduction band by an energy gap. Thermal activation can result in energization of some of the electrons in the valence band so that they have sufficient energy to jump to some of the lower levels of the unfilled conduction band. Because the number of conduction electrons in the conduction band is very small in comparison with the number of available empty levels in that band, these electrons move about with approximately equal ease. A similar statement applies to the holes occurring in the valence band.

By theoretical considerations, the number of electrons or holes in the semiconductor resulting from the generation of electron-hole pairs is given by the expression:

$$n = p = MT^{3/2} e^{-eV/2kT}$$

M = a constant
T = temperature, degrees absolute
V = the energy gap in electron volts
k = a constant (1.4×10^{-23} joules/degree) known as Boltzmann's constant
q = electron charge (1.6×10^{-19}) coulomb
It is clear that the product qV has the dimensions of coulomb-volts, or joules. Thus the ratio $qV/2kT$ is a dimensionless quantity.

The conductivity of a pure semiconductor may be derived as the expression —

$$\sigma = n\mu_n q + p\mu_p q = (\mu_n + \mu_p)\, qn,$$

since the number of thermally activated electrons equals the number of holes.
σ = conductivity *(mhos/cm)*
μ = mobility *(cm/sec per volt/cm)*
μ_n = mobility of electron
μ_p mobility of holes
Other quantities defined above.

The mobility, μ, is the average drift velocity acquired by electrons or holes in the direction of an applied field of one volt/cm.

Combine the two expressions presented above:

$$\sigma = MT^{3/2} e^{-Vq/2kT} (\mu_n + \mu_p)\, q \text{ mhos/cm}$$

At such temperatures that the only significant current carriers are thermally generated hole-electron pairs,
μ varies approximately as $1/T^{3/2}$
therefore

$$p = Ne^{-Vq/2kT}$$

where N is a temperature independent constant. Resistivity may be expressed as

$$p = 1/Ne^{-Vq/2kT}$$

Note the characteristic expression for thermistor resistivity decreasing exponentially with increasing temperature. The principal constants $1/N$, and $Vq/2k$ are properties of the semiconductor material.

TABLE IV • Thermistor Applications as recommended by Thermistor Division, Gulton Industries

Problem	using a GLENNITE Thermistor will provide:	because of these characteristics:	GLENNITE type recommended:	for the approxima range:
temperature sensing				
a. temperature measurement	quick response, small size, simple related circuitry, remote location	resistance of thermistor is dependent on ambient temperature	bead, bead in glass probe, bead in metal probe	–60°C to +400°
b. temperature alarm and c. temperature control	large resistance change with slight change in temperature	change in resistance used to activate relay	bead, bead in glass probe	–60°C to +400°
temperature compensation	compensation in transistor circuits, compensation for materials with positive coefficients	exhibits negative temperature coefficient	wafer	–60°C to +150°
amplitude control				
a. oscillator amplitude stabilization b. gain control	feedback voltage variation to compensate for any input changes, regulation over varying ambients	sensitive to change in output signal	bead, bead with heater	wide range of amplitude and frequency
c. RMS voltage regulation	close voltage regulation for wide range of load resistances and voltage supplies	change in voltage causes inverse change in thermistor resistance	wafer, rod, bead in bulb	fraction of volt to 110 volts
d. volume limiting	constant signal level output without wave distortion	operates on negative slope part I-E curve	bead in bulb	audio frequency range
time delay				
a. time delay	small size, long life, ruggedness, no moving parts	thermistor resistance change regulates current flow resulting in variable or fixed delay	wafer, rod, bead in cartridge	fraction of a seco to several minute
b. elimination of false operation of relays	high resistance to limit initial current flow		wafer, rod	seconds to minut
c. surge suppression	insurance against current surge preventing vacuum tube burnout while being self-regulating	response time of thermistor	wafer, rod	seconds to minut
measurements and analyses				
a. liquid level detection	remote indication, small size	differential cooling of self-heated thermistor according to conductivity of its surroundings	bead, bead with heater	level change ±.1
b. flow measurement	free flow without interference, very small size			
c. wind velocity	free flow without interference, very small size		bead, bead with heater	10^{-3} to 10^{3} cu. ft./min.
d. gas analysis e. manometry	instantaneous response, will not absorb or react with gas		bead	10 ppm 10 to 5000 micro

TABLE V

THERMISTORS MANUFACTURERS

AIRBORNE ACCESSORIES CO.
1414 Chestnut Ave., Hillside, N. J.

ASTRO TECH.
3014 Halladay St., Santa Ana, Calif.

BARNES ENGINEERING CO.
30 Commerce Rd., Stamford, Conn.

CARBORUNDUM CO. *Refractories Div.*
Perth Amboy, N. J.

FXR, INC.
26-12 Borough Pl., Woodside, N. Y.

FENWAL ELECTRONICS, INC.
33 Mellen St., Framingham, Mass.

FERROXCUBE CORP. OF AMERICA
149 E. Bridge, Saugerties, N. Y.

GC ELECTRONICS CO., Chem. & Tool Div.
400 So. Wyman St., Rockford, Ill.

G. M. MFG. CO.
134 W. 26th St., New York, N. Y.

GARRETT CORP. AIRESEARCH MFG. DIV.
9851 S. Sepulveda, Los Angeles, Calif.

GENERAL ELECTRIC CO. Mil. Elctrns. Dept.
Court St., Syracuse, New York

GENERAL ELECTRIC CO. Magnetic Mat. Sect.
7794 N. Neff Rd., Edmore, Mich.

GLENCO CORP., SUB. GULTON INDUSTRIES, INC.
212 Durham Ave., Metuchen, N. J.

KAHN & CO.
885 Wells Rd., Hartford, Conn.

KEYSTONE CARBON CO., INC.
1935 State St., St. Mary's Pa.

KIDDE, WALTER & CO., INC.
277 Main St., Belleville, N. J.

METARAC, INC.
45-68 162 St., Flushing, N. Y.

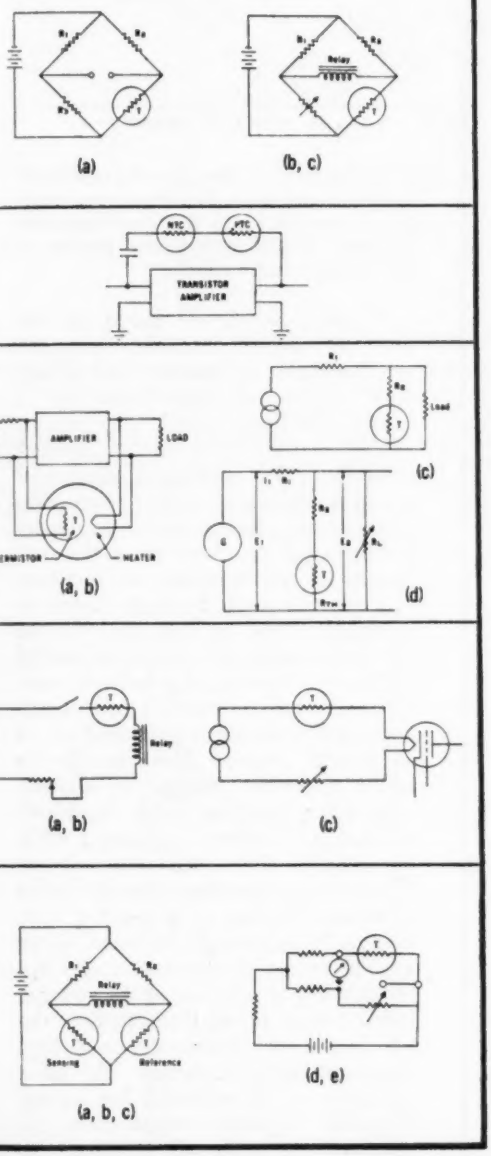
MARSHALL INSTRUMENT
14204 Bessemer, Van Nuys, Calif.

NACIMCO PRODS.
Old San Diego Sta., San Diego, Calif.

NARDA MICROWAVE CORP.
118-160 Herricks Rd., Mineola, N. Y.

NUCLEONIC PRODUCTS CO., INC.
1601 Grande Vista Ave., Los Angeles, C

with the following
typical circuitry:



RADAR MEASUREMENTS CORP.
190 Duffy Ave., Hicksville, L. I., N. Y.
TEMP RESISTORS INC.
Big Rapids, Mich.
THERMALIC CORP.
18743 Lull St., Van Nuys, Calif.
THERMO PRODS. CO.
3727 N. Palmer St., Milwaukee, Wis.
THERMOCAL, INC.
1631 Colorado Ave., Santa Monica, Calif.
VICTORY ENGINEERING CORP.
P. O. Box 373, Union, N. J.
WALSCO ELECTRONICS MFG. CO.
Div. Textron
400 S. Wyman St., Rockford, Ill.
WIEGAND, EDWIN L. CO.
7500 Thomas Blvd., Pittsburgh, Pa.

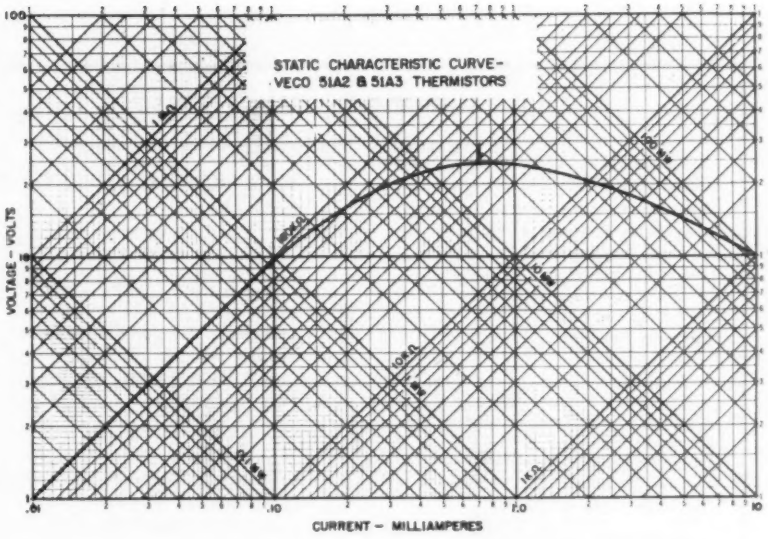


Fig 3A Static characteristics of a Victory Engineering Corp. thermistor illustrating a convenient method of representing thermistor behavior including the effects of self heating.

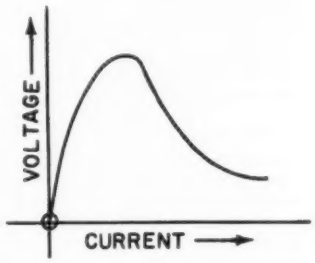


Fig 3B Characteristic shape of thermistor curve on a linear scale.

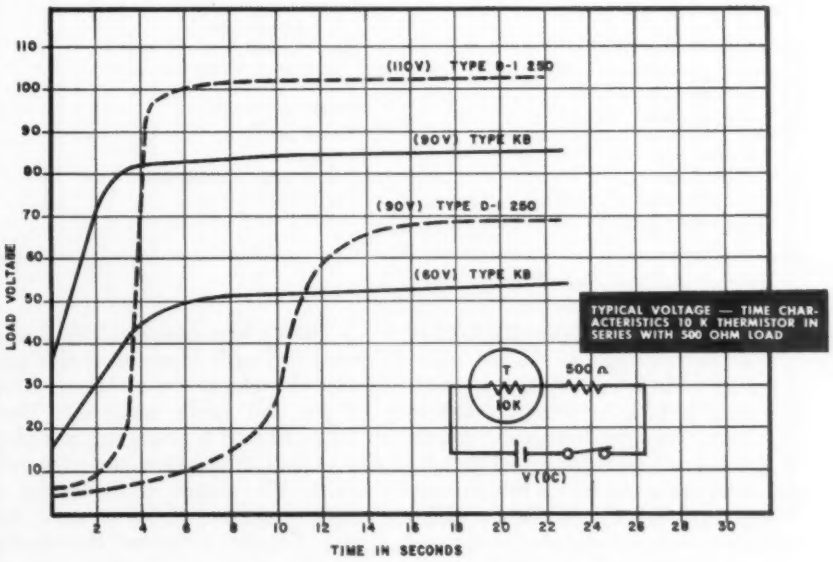


Fig 4 Voltage-current characteristic of bead thermistor in series circuit illustrating the time delay introduced by self-heating. *Courtesy of Walter Kidde & Co., Inc.*

COMPONENTS DIGEST

THERMISTOR APPLICATIONS

as suggested by Victory Engineering Corp.

COMMUNICATIONS
- Ambient Temperature Compensation
- Time Delay Devices
- Voltage Regulators
- Overload Protectors
- Remote Controlled Resistance
- Switching Devices
- Negative Resistors
  - Oscillators
  - Amplifiers
  - Transmission Networks
- Amplitude Stabilized Oscillators
- Power Indicators
- Compressors and Expanders
- Volume Limiters
- Automatic Gain Regulators

MINING AND METALLURGY
- Fire Protection and Safety Devices
- Gas Detectors
- Pyrometry
- Quality Control
- Time Delay Devices
- Geological Temperature Surveys
- Calorimetry
- Local and Remote Temperature Measurement and Control

TRANSPORTATION
- Engine Temperature Measurement and Control
- Flow Meters
- Switching and Signalling Devices
- Differential Temperature Controllers
- Fire Protection and Safety Devices
- Test Equipment
- Aircraft Cabin Temperature Control
- Meteorological Equipment
- Wing Temperature Measurement for Aircraft
- Aircraft Anti-icing Control

HOUSING AND HOUSEHOLD APPLIANCES
- Automatic Switches
- Fire Protection Devices
- Automatic Room Temperature Control
- Air Conditioning Systems Control
- Gas Detectors
- Furnace Controls
- Oven Temperature Control
- Refrigeration Control

MANUFACTURING
- Quality Control
- Fire Protection Devices
- Temperature Measurement and Control
- Surge Suppressors
- Anemometry
- Flow Meters
- Differential Temperature Controllers
- Vacuum Gauges
- Automatic Switching
- Time Delay Devices
- Voltage Regulators
- Pyrometry

CHEMICAL AND FOOD PROCESSING
- Calorimetry
- Local and Remote Temp. Indication
- Chemical Analysis
- Automatic Temperature Control
- Gas Detectors
- Refrigeration Control
- Pyrometry
- Vacuum Gauges
- Temperature Compensation

PUBLIC UTILITIES
- Voltage Regulation
- Time Delay Devices
- Warning Devices
- Gas Detectors
- Flow Meters
- Anemometry
- Chemical Analysis and Control
- Power Indicators
- Temp. Compensation of Instruments
- Switching Devices
- Calorimetry
- Pyrometry

MEDICAL AND SCIENTIFIC
- Temperature Measurement of Blood in the Human Body
- Subcutaneous Skin and Muscle Temperature Measurement

INSTRUMENTATION
- Power Indicators
- Pyrometry
- Meteorological Equipment
- Vacuum Gauges
- Temperature Compensation

VOLTAGE-SENSITIVE VARISTORS

Semiconductor materials are available that exhibit a large change in resistance characteristic as a function of applied voltage while maintaining symmetry with respect to the polarity of the applied voltage. An a-c signal applied to such a symmetrical varistor will not develop a d-c rectified current component as would occur for example in a non-symmetrical device such as a rectifier.

The earliest commercially available semiconductor material of this nature was developed by General Electric under the trade name of Thyrite. This material is widely used today in a variety of applications as noted in Table VI. Figure 6 shows the volt-ampere characteristics of some standard Thyrite varistors manufactured by the General Electric Company. Figure 7 shows typical varistor characteristics on linear and logarithmic coordinates.

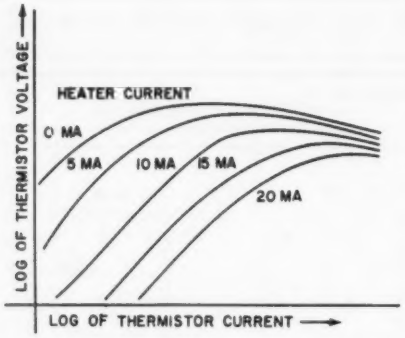


Fig 5 Static characteristics of a separately heated thermistor. The curves are similar to those of Fig 3, but here constitute an entire family with heater current as the independent variable.

These varistors are based on the use of silicon carbide, properly crushed into a powder and mixed with additional ingredients in a binder, and heat treated. The interior of the resulting hard varistor element behaves as if it contains a mixture of p and n regions in contact to provide rectification characteristics at many localized points. Because of the uniformity of the material, the rectification occurs equally for both directions of current flow so that there is no net d-c as explained above; hence the symmetry. The varistor behaves very much as if it consisted of two identical parallel rectifiers polarized so as to permit current flow equally in either direction. Table VII, starting with some basic formulas developed in solid state theory (presented without proof), shows this equivalence. The volt-ampere characteristic curve is similar to that of a rectifier conducting in its forward direction. Over a wide range, the current varies approximately as a power of the voltage, varying from about three to five, depending on the composition and heat treatment of the material. The basic resistivity of the material has an appreciable negative temperature coefficient. As with all resistive elements, the actual resistance value is a function of geometry, increasing with length of path, and decreasing with increased cross-sectional area.

Where the application of a symmetrical varistor requires calculation and circuit analysis, the reader is referred to "The Calculation of Circuits Containing Thyrite Varistors" by Theodore Brownlee, published in the General Electric Review. This informative article presents fundamental equations and analyses of circuits combining Thyrite and resistive and reactive elements. Waveforms and harmonics are investigated analytically.

The nomograph of Fig 8 (by Ferroxcube Corporation of America) is

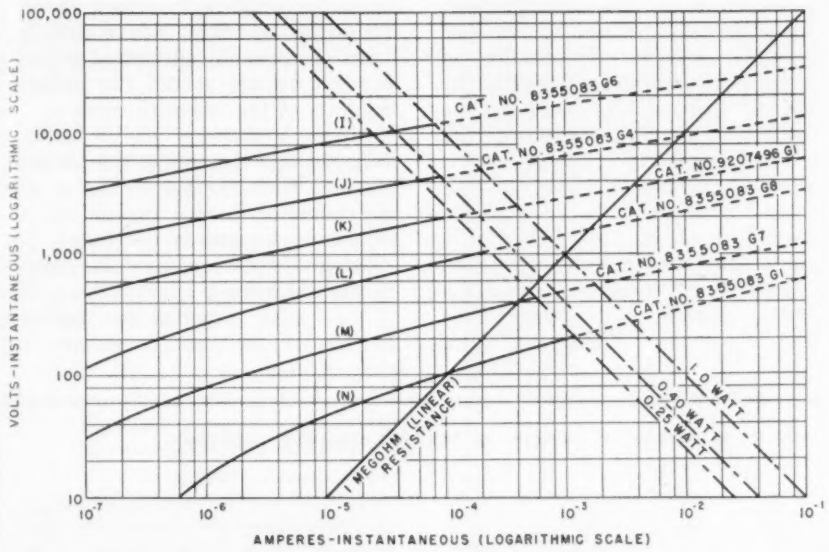


Fig 6 Typical volt-amphere characteristic of representative G.E. Thyrite resistor rods of ¼ inch diameter, having several resistance levels. Characteristic of one megohm resistance is shown for comparison. Thyrite resistors such as are represented on the above curves are available with a wide range of electrical characteristics, shapes and sizes, and power ratings. Thyrite has negligible change with time, can be operated indefinitely without change of characteristics, and exhibits the same response to microsecond impulses as it does to slowly changing signals. *Courtesy of General Electric Co.*

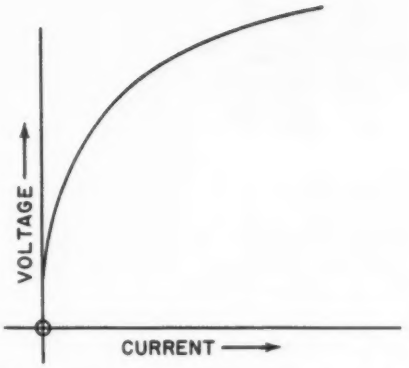


Fig 7A Linear coordinate representation of voltage-current characteristic.

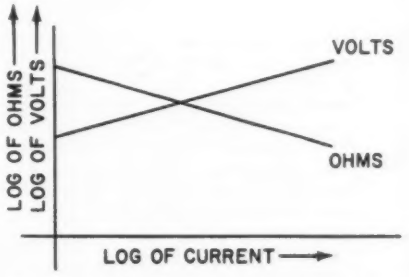


Fig 7B Theoretical characteristic of symmetrical silicon carbide varistor on logarithmic coordinates. For a current range of 10^5, voltage increases by about 30:1, and resistance decreases by over 3000.

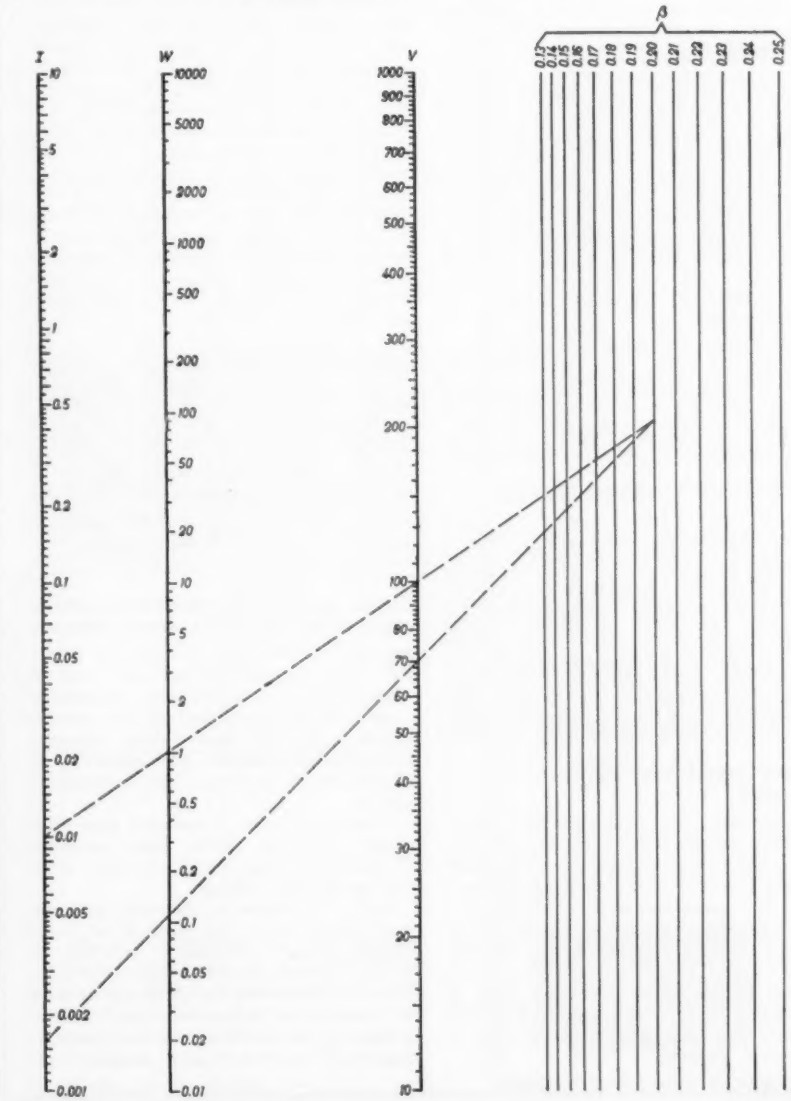


Fig 8 Nomogram giving the relation between voltage, current, power dissipation and β value of any VDR. *Courtesy of Ferroxcube Corp. of America, Saugerties, N.Y.*

an aid to the calculation of circuits using Thyrite. Table VIII is a partial list of varistor manufacturers.

THE ZENER DIODE

The Zener diode is a semiconductor diode whose application is based upon the sharpness and stability of its reverse breakdown characteristic. Before discussing this unit in detail, we reconsider some properties of the p-n junction, reviewing and extending information presented in Part II of this series. To be practical we limit consideration to germanium and silicon devices.

When p- and n-type germanium or silicon are brought together to form a junction, a flow of charge carriers takes place across the junction to unbalance the hitherto neutral separate members. The charge flow occurs by diffusion which appears whenever there is a gradient in the density of the carriers, the direction of flow being away from the region of highest concentration. The holes in the p region and the electrons in the n region diffuse over the junction at a rate

COMPONENTS DIGEST

proportional to the gradient of concentration (which is initially quite sharp across the junction) and to a diffusion coefficient which is a constant of the material.

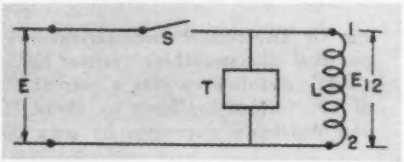
As a result of the flow of electrons and holes between hitherto neutral regions, the n material becomes positively charged and the p material negatively charged. Eventually an electric field builds up between the positively charged n material and the negatively charged p material, with the charge carriers concentrated on opposing sides of the junction. This electrical field across the junction eventually leads to a flow of minority carriers (holes in the n region and electrons in the p region) across the junction opposite in direction to the diffusion currents. Eventually there is an equilibrium in which there is no net current flow, where drift currents of thermally generated minority carriers exactly match the diffusion currents of the majority carriers.

Upon application of an external voltage such that the p side is made positive with respect to the n side, the potential barrier created by the diffusion currents is decreased, permitting a large increase in current. When a voltage is applied that makes p side more negative the potential barrier is increased, reducing the

TABLE VI • CIRCUIT APPLICATIONS FOR THYRITE, A SYMMETRICAL VOLTAGE SENSITIVE VARISTOR.

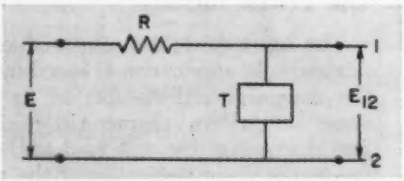
Courtesy of General Electric Co., Edmore, Mich.

Many applications of Thyrite to electric circuits are possible. A few general types of application to basic circuits are shown below. Applications to other circuits are, of course, possible, including those involving inductance, capacitance, and electronic tubes. The letter (T) designates Thyrite, and (R) designates constant (linear) resistance; the load terminals are 1 and 2, and the supply voltage is E.



ABSORPTION OF STORED ENERGY

Fig VI-a The voltage, E_{12}, which tends to increase when the switch opens (surge overvoltage due to L di/dt), can usually be limited to a safe value. By proper design, the current passed by Thyrite at normal voltage will be negligible.

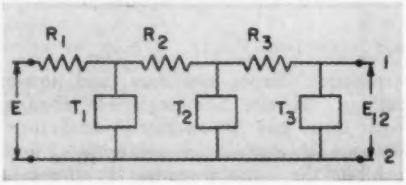


PROTECTION

Fig VI-b Thyrite is applied in parallel with the load to limit the load voltage E_{12}. Because of the high exponent, the Thyrite current at normal voltage can be small, but will increase rapidly as the voltage E rises above normal.

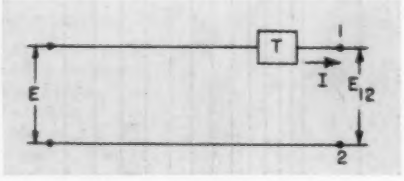
STABILIZATION OF LOAD VOLTAGE (Constant Load)

A change in the load voltage, E_{12}, can be small compared to the change in the applied voltage E, as a small increase in E_{12} causes a large increase in the Thyrite current and in the voltage drop across R. The greatest effect occurs when R is large compared to the effective resistance of the Thyrite, and the Thyrite current is large in proportion to the load current. Under these conditions the percent rise in E_{12} will approach 1/n times the percent rise in E. This circuit can be used to make an amplifier response relatively independent of the input signal strength by connecting the grid to terminal 1, shown in Fig VIb; distortions will be introduced.



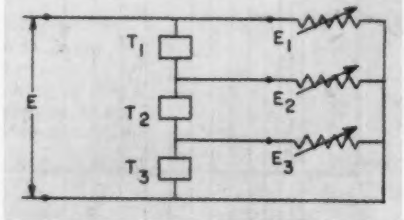
CASCADE CIRCUIT TO REDUCE VARIATIONS IN LOAD VOLTAGE

Fig VI-c Several circuits such as Fig VI-b may be connected in series, as in Fig VI-c, to produce an even greater stabilization of load voltage.



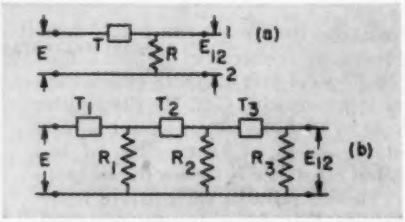
STABILIZATION OF LOAD VOLTAGE (Variable Load)

Fig VI-d When a variable load is connected to a constant source of voltage E through a Thyrite dropping resistor T, large changes in load current I result in relatively small changes in voltage across the Thyrite. Thus the load voltage E_{12} remains relatively constant.



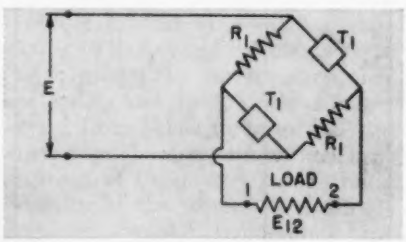
POTENTIOMETER WITH CONSTANT TAP VOLTAGES

Fig VI-e When Thyrite is used as a potentiometer, the variations in the tap voltages E_1, E_2, and E_3 due to variations in the load currents I_1, I_2, and I_3, will be much less than those in a potentiometer made of constant resistances. The effectiveness of the Thyrite potentiometer in maintaining relatively constant voltage division among the taps is greater if the Thyrite current is large in comparison to the load current. Distortion in wave form may be of importance on alternating voltages.



LOAD VOLTAGE SENSITIVE TO VARIATION IN INPUT VOLTAGE

Fig VI-f The variation in load voltage E_{12} will exceed the variation in the applied voltage E (see Figure VI-f (a). For example, the per cent change in E_{12} can approach n times the change in the applied voltage, if R is small compared with the Thyrite resistance, and if the load current is small. A greater change can be obtained by using several circuits in series, as in Fig VI-f (b). These circuits give an increased sensitivity to voltage change, but cannot amplify power, because the resistances consume energy. The load voltage is always less than the input voltage, unless transformers are used.



BRIDGE CIRCUITS FOR CONSTANT VOLTAGE REGULATION AND FOR CONTROL CIRCUITS

Fig VI-g As the input voltage E is raised, the load voltage E_{12} increases until it reaches a maximum; and when the Thyrite current equals the current in the constant resistance R_1, the load voltage becomes zero. Further increases in E cause E_{12} to reverse and to increase with the opposite polarity.

When this circuit is operated near load-voltage maximum, rather large variations in applied voltage result in only small changes in load voltage.

When the circuit is operated near the load-voltage zero, the reversal of load-voltage polarity provides a sensitive response to small changes in applied voltage. With this adjustment, the circuit can be used in circuit-control equipment; for example, a thyratron can be "fired" by the change in polarity of E_{12}, due to small increase in E.

current to a very low value. This provides the rectification characteristic previously described.

Reverse Breakdown

When a p-n junction is subjected to a sufficiently high externally applied reverse voltage, breakdown occurs. In modern germanium and silicon devices that utilize this breakdown, the predominant mechanism is an avalanche effect.

Consider the reverse biased p-n junction. Here the p region is made negative with respect to the n region so that the majority carriers withdraw from the junction. Nonetheless the minority carriers, generated typically by thermal excitation flow across the junction to constitute the reverse leakage current of the rectifying junction. Because the junction can be made extremely narrow by design, it is possible to develop electric field gradients within the material of the order of several hundred thousand volts per cm. At these field strengths the minority carriers may be accelerated to such high velocities that upon collision they can strip off valence electrons of the atoms in the vicinity, creating additional electron-hole pairs. The new carriers in their turn are accelerated to create by collision additional electron-hole pairs leading to an avalanche or multiplication effect. There follows a tremendous increase of reverse current, Fig 9. The breakdown voltage for silicon and germanium junctions is adjusted by controlling the impurities which establish the resistivity.

Although the avalance effect is the predominant mechanism of breakdown, other effects also occur. Probably as understanding and control of semiconductor processes is improved, these other effects can be minimized in importance to secure

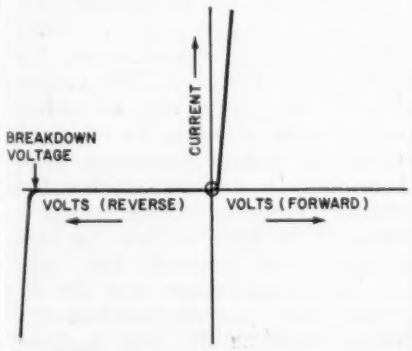
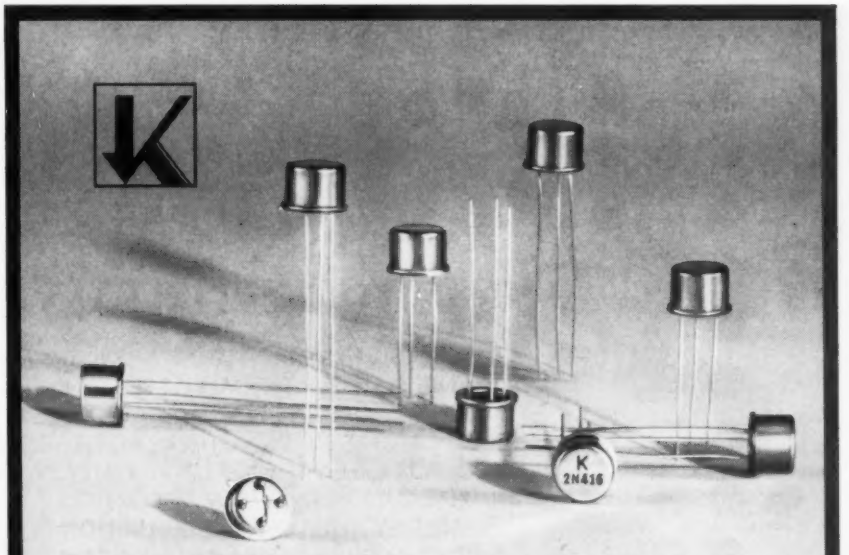


Fig 9A Characteristic curve of typical avalanche diode on a uniform linear scale. The abrupt large increase in current in the reverse direction shows the avalanche effect. A linear scale such as this is inadequate to show pertinent parameters of the diode.



KEARFOTT TRANSISTORS PROVIDE HIGH RELIABILITY-CONSISTENT PERFORMANCE

HIGHEST POWER DISSIPATION OF ALL AVAILABLE GERMANIUM-ALLOY JUNCTION TRANSISTORS

Kearfott now offers a complete off-the-shelf series of TO-5 germanium-alloy PNP junction transistors. Their unexcelled electrical and mechanical reliability, precise electrical characteristics, and virtual insensitivity to temperature changes derive from Kearfott's intensive materials-and-methods control, plus complete, 100% functional testing. These factors add up to the consistent reliability, uniformity, extended service life, and repeatability of product performance which typify Kearfott semiconductors.

DESIGNED AND PRODUCED BY KEARFOTT SEMICONDUCTOR CORP. WEST NEWTON, MASS.

CHARACTERISTICS

Meet or exceed requirements of NAVORD OS9669B (R-212 Series) and MIL-S-19500B

All transistors tabulated below are available with maximum collector power dissipation of 200 mw.

2N123	2N404	2N520A	2N653
2N315	2N404A	2N521	2N658
2N315A	2N413	2N521A	2N659
2N316	2N414	2N522	2N660
2N316A	2N414A	2N522A	2N661
2N317	2N416	2N523	2N662
2N317A	2N425	2N523A	2N1017
2N394	2N426	2N578	2N1303
2N395	2N427	2N579	2N1305
2N396	2N428	2N580	2N1307
2N396A	2N519	2N581	2N1309
2N397	2N520	2N582	

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 42 ON INQUIRY CARD

IS *YOUR* DISPLAY?

ARE YOUR SIGNALS CLEAR? DON'T TRUST TO CHANCE . . . OR THE MEDICINE MAN. FOLLOW THE PATH OF THE "CELCO" GUIDE THAT HAS HELPED OTHERS BEFORE YOU. FOR CRITICAL SPOT UNIFORMITY, HIGH RESOLUTION AND LOW DISTORTION . . . SPECIFY THE "CELCO" **DEFLECTION YOKE.** FOR PRECISION MILITARY AND COMMERCIAL DISPLAYS, "CELCO" OFFERS STANDARD YOKES IN 7/8", 1", 1-7/16", & 2" CRT NECK DIAMETERS. ALSO AVAILABLE IN 2-1/8" & 2-1/2" CRT NECK DIAMETERS. FOR PRECISE FOCUS, MINIMUM FRINGING, AND DESIGN ENGINEERING BEYOND THE "STATE OF THE ART", SPECIFY "CELCO" FOCUS COILS. FOR IMMEDIATE ENGINEERING ASSISTANCE CALL YOUR NEAREST "CELCO" PLANT OR WRITE FOR THE **"CELCO" DEFLECTION YOKE CATALOG** AND LET THIS BE YOUR GUIDE TO BETTER DISPLAYS.

Constantine Engineering Laboratories Co.

(MAIN PLANT) BOX 555, MAHWAH, N. J. DAVIS 7-1123 - 7-1124
PACIFIC DIVISION — 1150 E. 8th St. UPLAND, CALIF. YUkon 2-0215

CIRCLE NO. 43 ON INQUIRY CARD

COMPONENTS DIGEST

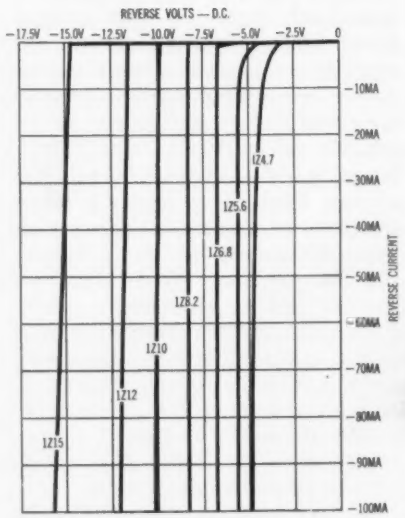


Fig 9B Reverse current curves of typical Zener diodes by International Rectifier Corp., El Segundo, Calif.

improved performance characteristics, and an extremely definitive breakdown point.

Diode Characteristics

Table IX and Fig 10 describe the specific characteristics of the Zener diode. Analysis of most Zener diode circuits is based upon superposition of load lines on the nonlinear diode characteristic to establish an operating point (just as is done in the load-line analysis of vacuum tube circuits). A-c operation is then readily analyzed in terms of a-c resistances (curve slopes) at the operating points. The analysis of most Zener diode circuits actually is very simple.

The sharp reverse breakdown point of the Zener diode provides the basic voltage reference on which many applications are based. A large variety of solid state power supplies utilize the avalanche voltage as the reference voltage for voltage regulation. The sharp impedance change above the critical breakdown voltage suggests the use of the Zener diode in arc suppression where relatively high voltage low energy surges may be involved. Many precision measurement devices including the most accurate digital voltmeters employ Zener reference voltages, although occasionally a calibration against a standard cell may be required. Applications in wave shaping (clipping) are self-evident.

A most significant characteristic of

Zener diodes is the a-c resistance (about a d-c operating level). This is really a measure of how sharp the slope is at the operating point. A vertical line (infinite slope) means a zero a-c impedance. Figure 11 shows the variation of a-c resistance with operating level in a typical diode. In voltage regulating applications a low a-c resistance is extremely important. Low a-c resistance is also important in filter applications where it is the ratio of d-c to a-c resistance that determines the quality of the filtering. In general a-c resistance falls off with increasing reverse current, but self-heating establishes a limit here.

A critical additional requirement is the need for stability of the breakdown voltage under a useful range of operating conditions. Long-term stability and temperature independence are the important parameters. The former is achieved through careful

TABLE VII

THEORETICAL EXPRESSION FOR SYMMETRICAL VARISTOR CHARACTERISTICS

Theoretically derived, the current through a *p-n* junction is given by the expression

$$I = I_{sat}(e^{qV_a/kT} - 1)$$

I = current through junction
I_{sat} = a constant (the uniform value of inverse current over a wide range of inverse voltage in an ideal *p-n* rectifier)
q = the electron charge, coulombs
V_a = applied voltage, volts
k = Boltzmann's constant
T = temperature, degrees absolute

For zero applied voltage the current I is zero. For a substantial negative

$$V_a\ I = I_{sat}$$

For a substantial positive V_a,

$$I = I_{sat}e^{qV_a/kT}$$

This expression applies essentially in the forward conducting direction not close to zero. Since, as explained elsewhere, the symmetrical varistor is roughly equivalent to the parallel arrangement of oppositely directed rectifiers, the expression should apply approximately over a suitably limited range. The expression may be expanded as a power series:

$$I = I_{sat}\,[1 + (qV_a/kT) + 1/2!\,(qV_a/kT)^2 + 1/3!(qV_a/kT)^3 + \ldots.]$$

If we examine this expression for increasing values of V_a, we discover that:

for qV_a/kT small,
$$I = I_{sat}(1 + qV_a/kT)$$

and that at higher values of qV_a/kT, terms increasingly along in the power series become important. For very high qV_a/kT, only the very high power terms contribute. These variations over the voltage range approximate the shape of the varistor curve including the curvature at the extremes of the *log I vs log* V_a plots. Over a useful intermediate range, the empirical approximations

$$I = CV_a^n \ (n \text{ between 3 and 5})$$

is applicable. This is the empirical form for the varistor characteristic as used in practical calculations. Power, parallel circuits, and other network parameters may be calculated, starting with this relationship.

RECORDING HEAD FERRITE

Kearfott's new CN-20 nickel-ferrite, specifically developed for recording head applications, is a sintered material which operates most efficiently in the 10 kc to 750 kc frequency range. CN-20 imparts superior magnetic and mechanical properties, is insensitive to mechanical stresses of potting compound during curing, is magnetically stable under temperature variation and has uniform magnetic properties. CN-20 heads have negligible deviations in inductance to temperatures as high as 160°F, using gaps of .0010 or .0015 inches.

Production quantities of complex shapes are immediately available. Dimensional tolerances of 0.0001 inch and finishes of 16 to 32 micro-inches are standard... electroplated surfaces for unusual wear resistance also available.

TYPICAL CHARACTERISTICS

Initial Permeability at 100 kc	800
Saturation Magnetization (DC) at 16 oersteds	3680 gauss
Residual Magnetization	2565 gauss
Coercive Force	0.19 oersteds
Temperature Coefficient of Initial Permeability (−20°C to +100°C)	1.0% °C
Curie Temperature	150°C
Resistivity	10^4 ohm-cm

All magnetic properties are held within a tolerance of ±15%

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 44 ON INQUIRY CARD

COMPONENTS DIGEST

control of the manufacturing processes, while the latter item may require temperature compensation.

Figure 12 shows the way breakdown voltage varies with temperature. Figure 13 shows how a silicon diode, whose temperature coefficient in the forward direction has a sign opposite to that of the coefficient of the breakdown voltage may provide compensation. The curve of compensated temperature characteristic is shown in Figure 14. Where much wider bands or high temperature stability are required, ovens may be used to hold temperature variation within close limits.

It must be borne in mind that the

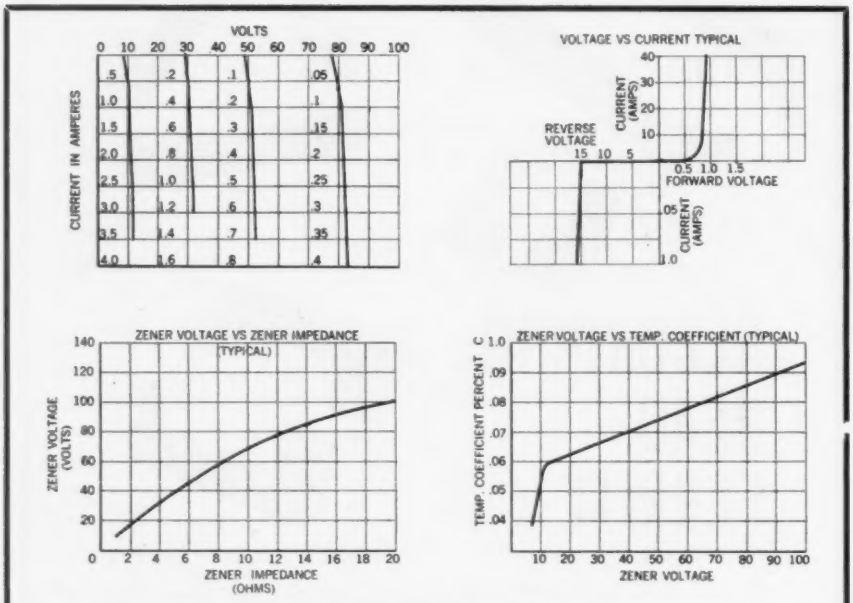


Fig 10 Typical Zener diode characteristics. *Courtesy U.S. Semiconductor Products, Inc.*

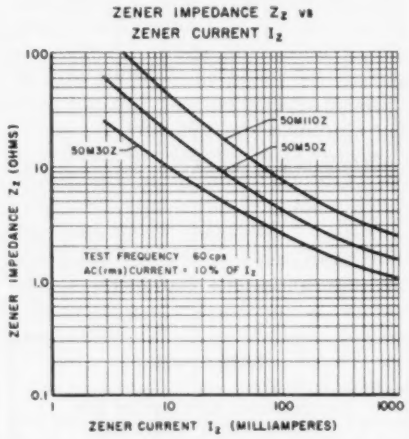
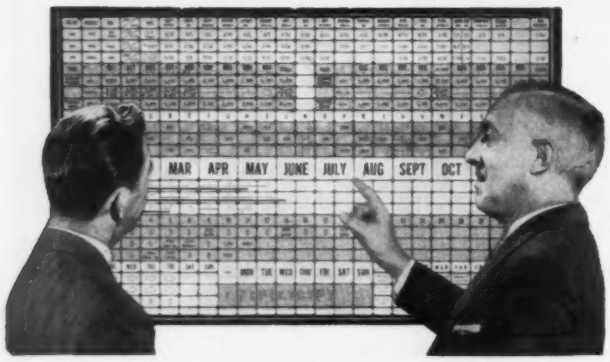


Fig 11 Variation of Zener impedance with Zener current, measured by applying a 10% ac current superimposed on the breakdown current. *Courtesy of Motorola, Inc.*

How To Get Things Done



BOARDMASTER VISUAL CONTROL

Gives you a Graphic Picture of your operations, spot-lighted in color. You See what is happening at a glance. Facts at eye level – saves you time, prevents errors.

Simple, flexible – easily adapted to your needs. Easy to operate. Type or write on interchangeable cards, snap in grooves. Ideal for production, scheduling, sales, traffic, inventory, etc. Made of metal. Compact, attractive.

Full price $49.50 with cards

FREE 24-Page Illustrated Booklet AK-20 Mailed Without Obligation

GRAPHIC SYSTEMS, Yanceyville, North Carolina

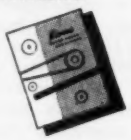
CIRCLE NO. 67 ON INQUIRY CARD

MORE DESIGN FREEDOM

SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials.

NEW CATALOG



Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

SIERRA ENGINEERING CO.
123 E. Montecito Sierra Madre, Calif.

CIRCLE NO. 66 ON INQUIRY CARD

TABLE VIII

VARISTORS MANUFACTURERS

BRADLEY SEMICONDUCTOR CORP.
275 Welton St., New Haven, Conn.

CARBORUNDUM CO. *Refractories Div.*
Perth Amboy, N. J.
Springfield Rd., Union, N. J.

GENERAL ELECTRIC CO.
Mag. Mat. Section
Edmore, Mich.

INTERNATIONAL RESISTANCE CO.
Boone, N. C.

METARAC, INC.
45-68 162 St., Flushing, N. Y.

NUCLEONIC PRODUCTS CO.
1601 Grande Vista Ave., L. A., Calif.

TRANSITRON ELECTRONIC CORP.
168-182 Albion St., Wakefield, Mass.

VICKERS, INC. *Electric Prods. Div.*
1825 Locust St., St. Louis, Mo.

VICTORY ENGINEERING CORP.

FERROXCUBE CORP. OF AMERICA
149 E. Bridge St., Saugerties, N. Y.

TABLE IX

ZENER DIODE PERFORMANCE CHARACTERISTICS
(as formulated by U.S. Semiconductor Products Corp.

Performance Characteristcs

Zener (or breakdown) Voltage: The breakdown of a reversed-biased semiconductor diode is reversible, and does not destroy the diode as long as the current through the diode is limited to a safe value. The sharpness of this breakdown as it occurs in silicon accounts for the usefulness of silicon Zener diodes as voltage regulators. The Zener voltage depends upon the current through the device since a Zener diode has some dynamic impedance. The specified Zener voltage thus applies only to the specified measuring current. The voltage to be expected at other currents can be calculated when the dynamic impedance is known.

Zener Impedance: The principle criteria for the quality of Zener diodes are the sharpness of the breakdown and the slope of the voltage-current curve beyond the breakdown point, which defines the Zener impedance. Fig 3A shows a composite picture of the back characteristics of several typical Zener diodes. It should be noted that the Zener breakdown is very abrupt over the entire Zener voltage range and Zener impedance is extremely low. At a given measuring current the Zener impedance will increase with increased Zener voltage. Zener impedance is measured by imposing a small ac current on a specified dc Zener current and taking the ratio of the incremental change in Zener voltage to the incremental change in Zener current.

The high crystalline perfection of the materials used in manufacture, as well as

(continued next page)

ANGLE COUNTER

KEARFOTT NAVIGATIONAL COUNTERS

Direct visual counter display provides the advantage of enabling lower valued increments of various angles to be easily read in terms of minutes and seconds of arc by means of relatively large size numerals. This advantage is achieved without the necessity of having vernier dials or similar devices. These counters are precision designed and their rugged construction assures a long life of trouble free service. B422 units are provided with either odometer or Geneva drives, while MK II units use Geneva drives. Gears, wheels, housings, and mounting flanges are constructed of durable materials, and Kearfott design techniques provide maximum readability in a relatively small amount of space. Kearfott counters operate reliably throughout a temperature range of −65°C to +90°C and meet the military requirements for shock, vibration, and case size.

FEATURES: ■ Long Operational Life ■ Compact Design ■ High Speed ■ Lightweight

CHARACTERISTICS:

All Counters Below Incorporate Geneva Drive

TYPE	PART NUMBER	NO. OF DIGITS	MAXIMUM COUNT	COUNTS PER REV.	MAXIMUM SPEED RPM	MAXIMUM BREAK AWAY TORQUE @ 20°C
B422 SERIES:[1]						
ANGLE	B422-□[2]	5	179° 59′	20′	1200	.75
(center scale)	C160432-□	5	179° 59′	20′	1200	.75
	C160431-□	6	179° 59.9′	2′	1200	1.0
	C160435-□	4	179.9°	2°	1200	.75
DECIMAL	C160433-□	3	99.9	2.0	1200	.75
(center scale)	C160434-□	4	999.9	2.0	1200	.75
MK II	MK 2 MOD 1	4	359.9	2.0°	1800	.35
Mod I	MK 3 MOD 1	3	359.	2.0°	1800	.35
SERIES:	C1604070043	4	359.9	2.0°	1800	.35
	A403-20B	4	359.9	2.0°	1800	.35

[1] Available in left or right Shaft, End or Side Mount, Mask readout of N-S, E-W, (+), (—)
[2] Same as C160432-□ except .040 shorter length (C160432 preferred for new designs)
[3] Available in various shaft extensions and white or bare aluminum numerals

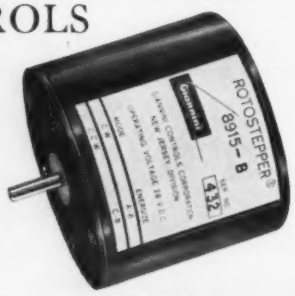
Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

CIRCLE NO. 46 ON INQUIRY CARD

YOU CAN SAY THIS AGAIN . . .

GIANNINI CONTROLS
STEPPING MOTORS
SCORE HIGH IN REPEATABILITY



Trust them to stay in step with your repeatability requirements for critical applications. **Model 8915 Rotostepper:** Two-degree increments, clockwise or counterclockwise. Five-minute accuracy. Two-minute repeatability. Sixty-step-per-second rate. Two-million-step life. Available: homing, limit stops, automatic stepping, cardinal point stepping, internal potentiometer. **Model 1500C Servostepper:** Small (2.8 cu. in.), high torque (3 oz. in. at max. rate, half-degree steps), low power (14 watts during step only), high repeatability. For remote incremental shaft positioning, controlling of servos and resolvers, telemetered drone command, encoder positioning, or....? Send for Data Sheets.

ANOTHER SERVO COMPONENT FROM

Giannini Controls Corporation

A NAME TO PLAN WITH

1600 South Mountain Avenue, Duarte, California

SERVO COMPONENTS & SYSTEMS • AIR DATA INSTRUMENTS & SYSTEMS
INERTIAL INSTRUMENTS & SYSTEMS

Sales engineering offices: Glendale • Caldwell, N. J. • Pasadena • Denver • Palo Alto • Seattle
New York • Chicago • Dayton • Washington, D. C.

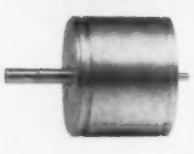
GCC 1-32

CIRCLE NO. 27 ON INQUIRY CARD

One Step Purchasing | **One Step Installation**

TIC

PACKAGED
PRECISION DRIVES



• TIC Drives save time, trouble and money — eliminate the need of procuring and assembling separate indicators, dials, knobs, gears, etc. And, with TIC Precision Drives you know you have a unit that will do the required job without a possibility of error. Use them with rotary components such as resolvers, synchros, potentiometers, inductors, capacitors, tuning coils, etc.

• TIC packaged Precision Dual Speed Drives are manually operated or motor driven, precision gear reducers to produce accurate shaft positioning with excellent readability. If your synchro, resolver, potentiometer or other rotary devices require precise positioning and readout, TIC Drives provide a complete package, including couplings and mounting hardware, to allow accurate and repeatable settings to within 1 minute of arc.

• No backlash. Meet MIL-E-4970 (USAF). Panel or Modular Mounts available. Gear Reductions up to 180 to 1.

Send for Complete Details.

TIC **TECHNOLOGY INSTRUMENT CORPORATION OF ACTON**
533 MAIN STREET, ACTON, MASSACHUSETTS

©12-60

CIRCLE NO. 36 ON INQUIRY CARD

COMPONENTS DIGEST

(continued from page 57)

the very thin silicon wafer, result in extremely low and uniform Zener impedance over a wide range of Zener current. This quality makes it especially useful as a voltage regulator.

Temperature Coefficient: The temperature coefficient is defined as the percent of voltage change per degree centigrade.

Temperature Dependence: The characteristics of silicon diodes are dependent on the temperature of the junction. As was noted above, the Zener voltage will shift as the junction temperature changes. The direction and the amount of voltage change from the voltage as measured at ambient or room temperature will depend on the original breakdown voltage as well as the temperature coefficient of the specified diode.

TABLE X

SOME COMMON ZENER DIODE APPLICATIONS

Sharp breakdown voltage, low ac impedance, stability and compactness make the Zener diode useful in a wide range of applications.

Zener diodes are used as voltage references for regulators, and for precision measuring equipment such as digital voltmeters, precision potentiometers, and analog digital converters. Temperature compensated units are required in these applications.

In a number of bridge circuits, Zener diodes provide the basic reference voltage for driving series or shunt transistors in the regulator circuits of dc power supplies.

Directly in shunt with the load, Zener diodes provide a fairly good regulation at low cost, for relatively low power applications. This is especially convenient in regulating tube voltages in precision electronic equipment.

Zener diodes can be used as the reference in constant current as well as constant voltage dc supplies.

AC voltages can be regulated by employing a pair of series-connected opposed Zener diodes which clip the ac peaks, generating an approximate square wave.

By limiting peak voltages, Zener diodes can provide surge protection in switching circuits. In circuit protection, they are often combined with fuses and relays. They can limit peak inverse voltages on transistors. They can also cut transient spikes in switching inductive and capacitive loads. Other aspects of surge protections are protections against line transients, and meter protection.

The low ratio of ac to dc impedance suggests use of the Zener diode as a coupling device in direct coupled amplifiers. In this application they replace a coupling capacitor. A similar application, say in cathode biasing of an amplifier, permits suitable biasing without use of a cathode by-pass capacitor, even at very low frequencies. Many more specialized circuits are used.

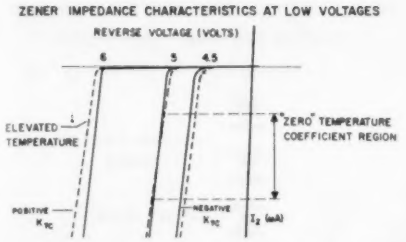


Fig 12A At higher Zener voltages, the avalanche effect is the predominant breakdown mechanism. Since this depends on the mobility of electrons and holes, which decreases at higher temperatures, the breakdown voltage increases indicating a positive temperature coefficient. At voltages below five or six volts the nature of the breakdown mechanism changes to the so-called Zener effect, which must be described in terms of quantum mechanical principles to be covered subsequently in this series. Zener effect breakdown is characterized by a negative temperature coefficient or a decrease in breakdown voltage with increasing temperature. At intermediate breakdown voltages a zero temperature coefficient region occurs.

Courtesy Motorola, Inc.

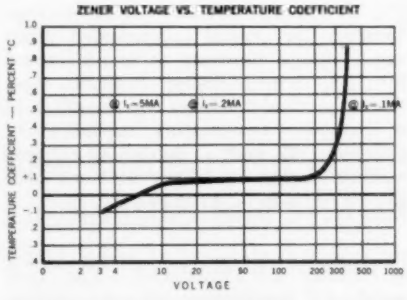


Fig 12(b) Curve showing temperature coefficient as a function of nominal Zener voltage. Typical characteristic by U. S. Semiconductor Products, Inc. Note that at lower voltages the test current increases although the safe power rating is not exceeded.

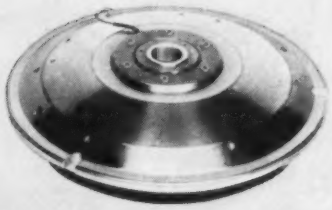
K_{TC} = TEMPERATURE COEFFICIENT

temperature we are considering is at the junction of the diode, and self-heating must be taken into consideration where it is considerable. The subject of heat dissipation and temperature rise and their relation to methods of installation and thermal resistance will be dealt with in a subsequent part of this series.

Table X lists some of the more common applications of Zener diodes. Table XI is a partial listing of Zener diode manufacturers who offer extensive and helpful application data.

POINT CONTACT RECTIFIERS

For high frequency applications it is necessary that stray capacitance in



KEARFOTT SYNCHROS AND RESOLVERS FOR GIMBAL APPLICATIONS

Precision wound components for direct mounting to gimbal structures are now available for application in gyros, platforms and other devices. These components can be supplied with or without appropriate precision bearings.

A wide range of mounting configurations are available and special adaptations can be provided. High accuracy components, featuring maximum error of 20 seconds of arc are in quantity production. Improved accuracy can be provided as required. Materials used as housing can be either aluminum or beryllium weight reduction. Stainless steel housings for rigidity and corrosion resistance are available in many standard units.

Typical gimbal mounted components are tabulated below. Special units are available with beryllium housings and include two multipole (equivalent to 25 speed) units with accuracy of 12 secs/speed. The CZ 06311 001 is a synchro transmitter, the CZ 09623 001 is a combination transmitter-DC torquer concentrically mounted. A "piggy-back," two unit transmitter, one 3 wire the other 4 wire with stack height of 1" is also available.

SPECIFICATIONS

Typical Part Numbers	Size	Function	Excitation	Accuracy
325720 325721	8	Resolver	2V 400 cps	15 min.
(Diameter .750". Length 1.250". See 3Z6390-001 below)				
3Z6390-001	25	Resolver Transmitter	20V 900 cps	3 min.
(Ring housing—special hub designed to operate concentrically around a smaller unit)				
CZ06360-002	As req'd.	Resolver Transmitter	115V 800 cps	20 sec.
(Pancake configuration beryllium housing 5.375" dia. X 1.437" high.)				
5Z6360-009	As req'd.	Resolver	115V 800 cps	3 min. or 5 min.
(Flat aluminum housing conforms to BuOrd 1980052-MIL-R-21530.)				
209981 209984	23	Resolver	As required	10 min.
(High accuracy machined stack allows direct mounting without housing.)				
3Z6210-006	25	Synchro	As required	2 min.
(Various hub and housing configurations available.)				
1/3Z6360-006	As req'd.	Resolver	115V 800 cps	20 sec.
(High accuracy transformation ratio 1.0160 conforms to BuOrd 1980055.)				

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 48 ON INQUIRY CARD

NEW... DETAILED DATA ON SERVO MOTORS

Here's information you can use to increase speed and accuracy in high precision control and measuring equipment . . . 4 fact-filled pages on Holtzer Cabot's line of R-24 Servo Motors.

Contains 3 sets of speed-torque, performance curves: (1) For four different stator stackings with 115V on both windings. (2) For four different stackings with 115V on fixed winding and 200V on control winding. (3) For 0.7″ of stator stacking with 115V on fixed winding and 200V, 100, and 50 on control winding. Gives additional data such as starting voltage, stall torque, rotor inertia, acceleration at stall, etc.

The R-24 Line has stator cores of 2.4″ diam., available with stacking lengths of 0.5″, 0.7″, 1.0″ and 1.4″. Models with or without gear trains. Send for your free copy of Bulletin MO-3.7A. Write: Holtzer-Cabot Motor Division, 125 Amory Street, Boston 19, Massachusetts.

HOLTZER NP CABOT

MOTOR DIVISION

National Pneumatic Co., Inc., Boston 19, Mass.

CIRCLE NO. 49 ON INQUIRY CARD

ZENER TEMPERATURE COMPENSATION WITH SILICON FORWARD JUNCTIONS.

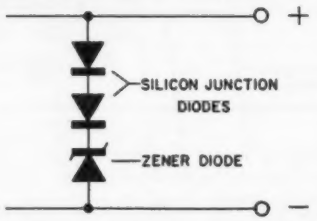


Fig 13 The forward drop of a silicon diode junction decreases with increasing temperature, suggesting the use of forward conducting diodes in series with the positive temperature coefficient Zener diode as a means of temperature compensation.

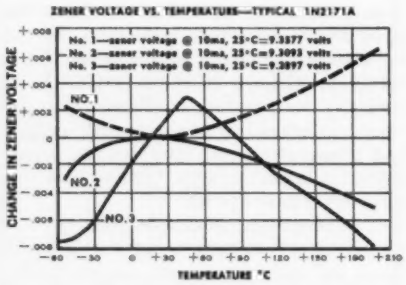

ZENER VOLTAGE VS. TEMPERATURE—TYPICAL 1N2171A
No. 1—zener voltage @ 10ma, 25°C=9.3577 volts
No. 2—zener voltage @ 10ma, 25°C=9.3093 volts
No. 3—zener voltage @ 10ma, 25°C=9.3897 volts
CHANGE IN ZENER VOLTAGE
NO. 1
NO. 2
NO. 3
TEMPERATURE °C

Fig 14 Change in Zener voltage vs temperature for typical compensated reference voltage elements as manufactured by U.S. Semiconductor Products, Inc. These particular diodes are specified at a maximum temperature coefficient of 0.0005%/°C and a maximum allowed voltage change of 12 mv at 10ma over the range —55°C to ±185°C.

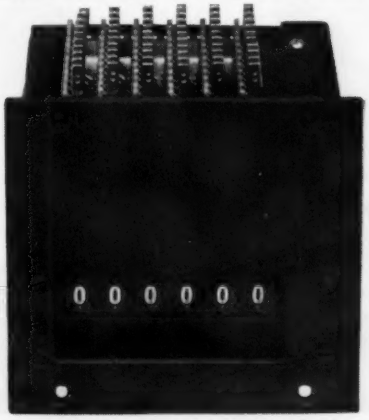
a rectifier be minimized. The R-C product (resistance times capacitance) extablishes the upper frequency limits.

With area contact rectifiers, the performance at high frequency depends to a significant extent on the product of capacitance across the contact area and forward resistance. Since capacitance increases with increased area, while forward resistance decreases, the product remains essentially unchanged, leaving no room for improvement in this direction. Point contact devices offered certain advantages in this respect when they initially appeared due to the spreading effects described below. However, improvements in the high frequency characteristics of junction devices have today led to the almost complete obsolescence of point contact area and forward resistance. computer and microwave applications.

Point contact rectifiers do however lead to improved high frequency characteristics based on certain mechanisms which help to explain aspects of transistor performance. Figure 15 shows a point contact rectifying junction, comparing the current flow paths

New Veeder-Root high speed digital readout counter meets new needs in automation and system design. It's precision engineered to record, display and electrically transmit accumulated digital levels. More than that, it's a fresh approach to a widening range of automation needs . . . an ingenious electrical link for digital indication, data recording, storage and transmission, automatic sequencing, predetermining control. See what this versatile unit can do for your equipment or designs. Write Electrical Section, Veeder-Root Inc., Hartford 2, Connecticut. **count on . . . VEEDER-ROOT.**

Series 1744 High-Speed Digital Readout Counter saves time and labor by eliminating manual counting and recording of production. It counts twice as fast, resets ten times as fast as previous units.

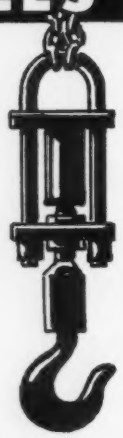


CIRCLE NO. 50 ON INQUIRY CARD

WEIGH ELECTRONICALLY

Ametron® CRANE SCALES

Designed for fast —easy Installation Visual or Printed Weights



Recorder may be mounted in crane cab or in other convenient locations. Prints tape or cards. Available at low costs in 5, 10 and 15 capacities. Rugged construction decreases maintenance.

Write for Brochure B 18

WRITE TO:

STREETER-AMET COMPANY
GRAYSLAKE, ILLINOIS
U.S.A.

CIRCLE NO. 51 ON INQUIRY CARD

PLASTIC EXTRUSIONS...ANY SHAPE OR SIZE

ACE is one of America's leading mass producers of plastic extrusions and all types of precision parts. Any shape, form or color. Any type of plastic. Small runs or large runs. Huge stocks for immediate delivery. Quick, low-cost service on specials. Write, wire or call for samples, price lists and technical bulletins.

SINCE 1934 A EXTRUDERS FABRICATORS

ACE PLASTIC COMPANY 91-44 VAN WYCK EXPWY · JAMAICA 35. N. Y.

CIRCLE NO 52 ON INQUIRY CARD

POTENTIO-METERS

RELIABILITY

DIGITO-METERS

ROTARY SWITCHES

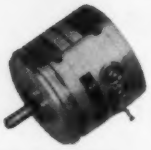
by ELECTRO-MEC

All our instruments offer you design flexibility and long life.

Step up reliability.

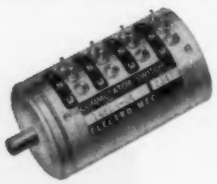
Step down size of your system.

POTENTIOMETERS: A complete line of superprecision linear and non-linear potentiometers. Certified calibration data, including recordings of output function are supplied with each instrument. All AIA sizes from RR-09 to RR-30.



DIGITOMETERS: Four sizes are available in this shaft angle digitalizer, 1.06" to 3.00" Dia. When you operate under severe ambient conditions, always specify Electro-Mec Digitometers. They are designed to withstand the rigors of MIL (E) 5272 environmental tests.

ROTARY SWITCHES: Our newest product with the same built-in reliability you have come to expect from Electro-Mec. .875" to 3.00" Dia., these Rotary Switches can be supplied singly or in combination with potentiometers. Current capacity up to 250 ma.



For further information or for data sheets, write or telephone our Engineering Department.

ST-6-3402 Teletype: NY-4-2126

ELECTRO-MEC DIVISION OF
WALTHAM PRECISION INSTRUMENT COMPANY, INC.
47-51 33 Street — Long Island City 1, N.Y.

CIRCLE NO. 35 ON INQUIRY CARD

COMPONENTS DIGEST

with those in a large area rectifying junction. Equipotential surfaces in the semiconducting material in the vicinity of the rectifying junction take a hemispherical shape. It is in this region in the close vicinity of the contact point that current flow lines are most crowded together, and the potential gradient is sharpest. As a matter of fact, regardless of the shape of the semiconductor body, the overall resistance depends predominantly on the geometry in the immediate vicinity of the point contact. (This assumes that the region of flow line congestion in the vicinity of the contact is small in comparison with the volume of the semiconductor.) This point is derivable on a rigorous basis from field theory in which it is demonstrated mathematically that a cylindrical conducting member in contact with a semi-infinite solid having a uniform resistivity exhibits a resistance which is inversely proportional to the diameter of the cylinder.

Consider now the relationship of this phenomenon to a rectifying contact. At the contact point the spreading out of flow lines during a forward or conducting interval leads to a resistance varying inversely as the contact diameter. During a reverse or non-conducting interval, where the rectification resistance occurs at the barrier area between contact and semiconductor, the resistance depends on the inverse square of the diameter. Thus the rectification ratio of reverse to forward resistance improves directly as the contact of the diameter decreases, hence the improved properties of the point contact diode. However, for small contact areas the current carrying capacity is reduced, so that these diodes are primarily used to handle low level signals.

Similar reasoning may be applied to the R-C product where R depends again inversely on contact diameter while C, essentially a barrier parameter, depends directly on the diameter squared. The upper frequency limit therefore increases inversely with the contact diameter. • • •

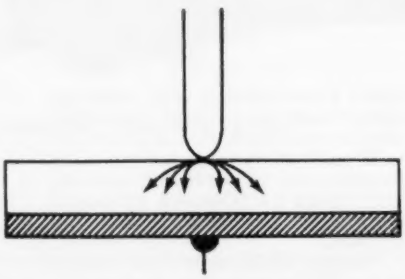


Fig 15 At a point contact junction, the flow of current is essentially radial from the junction. The principle resistance in the conducting direction occurs in the vicinity of the contact, with little resistance introduced by the semiconductor material remote from this region.

TABLE XI
ZENER DIODE MANUFACTURERS

AMPEREX ELECTRONIC CORP.
Box 418, 230 Duffy Ave.,
Hicksville, L. I., N. Y.

APPLIED RESEARCH INC.
76 South Bayles Ave.,
Pt. Washington, N. Y.

BOGUE ELECTRIC MFG. CO.
52 Iowa Ave., Paterson, N. J.

CBS ELECTRONICS
100 Endicott St., Danvers, Mass.

CONTINENTAL DEVICE CORP.
12911 S. Cerise, Hawthorne, Calif.

ELECTRONET, *Div. Rue Prods.*
4323 Corinth Ave., Culver City, Calif.

GENERAL INSTR. CORP.
Semiconductor Div.
65 Gouveneur St., Newark, N. J.

HOFFMAN ELECTRONICS CORP.
Semiconductor Div.
1001 N. Arden Dr., El Monte, Calif.

HUGHES PROD., HUGHES AIRCRAFT,
Semiconductor Div.
500 Superior Ave., Newport Beach, Calif.

ITT *Components Div.*
Box 412, Clifton, N. J.

INTL. ELECTRONICS CORP.
Mullard Equipment
81 Spring St., New York, N. Y.

INTL. RECTIFIER CORP.
1521 E. Grand Ave., El Segundo, Calif.

MOTOROLA, INC.
Semiconductor Prods. Div.
5005 E. McDowell Rd., Phoenix, Ariz.

NORTH AMERICAN ELECTRONICS, INC.
212 Broad St., Lynn, Mass.

PACIFIC SEMICONDUCTORS, INC.
10451 W. Jefferson Blvd.,
Culver City, Calif.

REGULATOR EQUIPMENT CORP.
52 Iowa Ave., Paterson, N. J.

SEMCOR
3536 W. Osborn Rd., Phoenix, Ariz.

SHOCKLEY TRANSISTOR CORP.
1117 California Ave., Palo Alto, Calif.

SYLVANIA ELECTRIC PRODS., INC.
1740 Broadway, N. Y. 19, N. Y.

TEXAS INSTRUMENTS, INC.
6000 Lemmon Ave., Dallas, Texas

TRANS-SIL CORP.
55 Hoeneck St., Englewood, N. J.

TRANSITRON ELECTRONIC CORP.
168-182 Albion St., Wakefield, Mass.

U.S. SEMICONDUCTOR PRODUCTS,
Div. UIC
3540 W. Osboon Rd., Phoenix, Ariz.

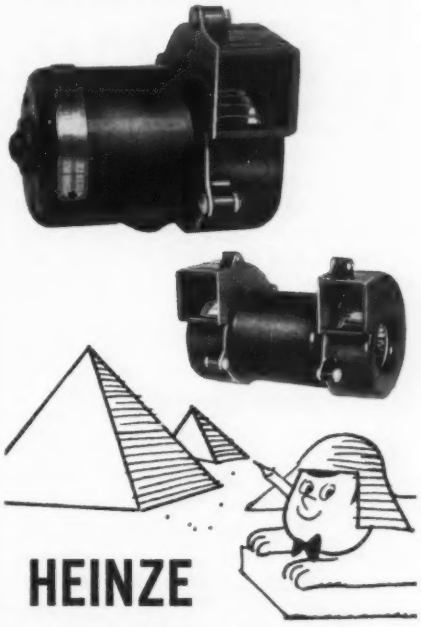
UCINITE CO. *Div. United Carr Fastener*
459 Watertown St., Newtonville, Mass.

VICTOREEN INSTR. CO.
5806 Hough Ave., Cleveland, Ohio

WESTINGHOUSE ELECTRIC CORP.
Semiconductor Dept.
Youngwood, Pa.

put HEINZE in your designs

BUILT TO LAST...



HEINZE
D 2½ BLOWERS

There are no brushes or commutators to wear out in the Type D 2 pole shaded pole induction motor which powers the Heinze D2½ Blower. You get long life, minimum maintenance, for such applications as dispersion of heat generated by electronic equipment, induction heaters, diathermy equipment, vending machines and in drying operations. D2½S Single Unit delivers 17 cfm (free air) at 3100 · rpm; D2½D Double Blower supplies 34 cfm (free air). Both blowers are enclosed in durable plastic — to withstand temperatures up to 230°F. Blowers operate on 115V, 60 cycle; they are available in other voltages and frequencies.

Send coupon for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St.
Lowell, Mass.

Sub-Fractional Horsepower Motors and Blowers

HEINZE ELECTRIC COMPANY
685 Lawrence St., Dept. ED
Lowell, Mass.
Please send complete catalog on Heinze Sub-Fractional Horsepower Motors and Blowers.

Name & Title_____

Company_____

Street & No._____

City & State_____

CIRCLE NO. 41 ON INQUIRY CARD

New Components For Electromechanical Systems

10 Watt Zener

Military type 10 watt zener diodes of 36 voltages ranging from 6.8 thru 200 in two polarities is expected to solve many design and non-standard parts approval problems. These new ±5% tolerance silicon units have a junction and storage temperature range of −65 to 175°C, and are supplied in a 7/16″ stud mount. Motorola, Inc., Phoenix, Ariz.

Write No. 325 in Box on Inquiry Card

Size 18 Motor-Generator

Temperature compensated motor generator exhibits the same features of magamp temperature-controlled units but at while also providing lighter weight, with longer life, and at lower cost. Linearity is less than 0.03%; frequency sensitivity, 0.015%/cycle; voltage sensitivity, 0.008%/volt; and temperature sensitivity of 0.05%. Kearfott Div., General Precision, Inc., Little Falls, N.J.

Write No. 322 in Box on Inquiry Card

25 Watt Rheostat

Resistive element of a new rheostat is wound on a fiber glass insulated aluminum core which is set in cement and bonded to a poreclain base. Shafts are insulated from all live parts. Standard resistance range is from 25 ohms to 500 ohms at ±10% tolerance. Tru-Ohm Products, Chicago, Ill.

Write No. 424 in Box on Inquiry Card

Inertial Switch

Subminiature inertial switch performs with high "g" accuracy even in the presence of superimposed shocks, steady-state vibrations and steady-state accelerations. The new switch, a cylinder 1 inch high by 1 inch in diameter, is a self-locking device that is resettable. Units are factory set to specified "g" levels from 5 to 25 g's. Response time, also preset, is between 25 and 200 milliseconds depending on the application. Sanders Associates, Inc., Nashua, N.H.

Write No. 314 in Box on Inquiry Card

Beryllium Oxide Heat Sinks

Used to insulate semiconductor devices from the chassis, new heat sinks use beryllium oxide's unique ability to resist the flow of electricity but not the flow of heat, allowing higher power without exceeding temperature limits. Previously available only in small quantities made to order, these dielectric heat sinks are now available from stock. National Beryllia Corp. claims that their heat sinks maintain semiconductor temperatures at least 50% lower for a given power level than those materials now used. National Beryllia Corp., Haskell, N.J.

Write No. 430 in Box on Inquiry Card

PNP Transistors

Having low collector cutoff current at high voltage and temperature, PNP germanium alloy transistors perform economically in control amplifiers for feedback and sensing circuits, in all applications requiring high gain and low noise characteristics. Hermetically sealed, they were subjected to a 100% hermetic seal test, and given 100 hours of high temperature bake. Temperature range: −65 to +85°C. General Electric Co., Liverpool, N. Y.

Write No. 525 in Box on Inquiry Card

FOR MORE RELIABILITY RESISTANCE POWER

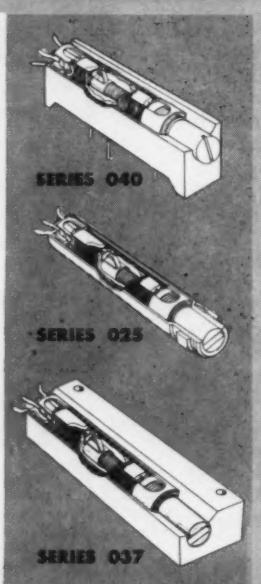
SPECIFY CON-ELCO®

FOR CIRCUIT TRIMMING BALANCING CALIBRATION

ALL CON-ELCO TRIMMING POTENTIOMETERS AND VARIABLE RESISTORS FEATURE RELIABILITY AND ACCURACY PREVIOUSLY UNAVAILABLE TO INDUSTRY FOR CIRCUIT TRIMMING, BALANCING AND CALIBRATION.

TYPICAL SPECIFICATIONS

Power Rating: 1w, 2w and 2¾ @ 50°C derate to 0 at 105°C, 150°C and 180°C
Temperature Range: —55°C to +105°C and 180°C
Resistance Range: 10 to 125,000 ohms
Humidity Seal: Mil-E-5272 Proc I and Mil-Std-202 Method 106
Terminals: Terminal configurations available include printed circuit pins, solder lugs and flexible leads.
Case: Several units are available in single or multiple unit rectangular cases.



CON-ELCO standard models are available from stock. Let CON-ELCO engineers help you with your application problems. Send for data today.

CON-ELCO®
A DIVISION OF EDCLIFF INSTRUMENTS
1711 South Mountain Avenue
Monrovia, California

CON-ELCO PROVIDES MORE RELIABILITY IN A SMALLER PACKAGE.

SEND FOR DATA

CIRCLE NO. 53 ON INQUIRY CARD

REVCO

ULTRA-LOW TEMPERATURE CABINETS

for

- Research
- Storage
- Seasoning
- Testing

Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to −140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

For your FREE copy of the helpful folder, "Selecting a low temperature cabinet," write Revco, Dept. EMD-61

Industrial Products Div.,
REVCO INC.
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

CIRCLE NO. 54 ON INQUIRY CARD

Precision Delay Lines

Group of high performance delay lines has a total delay of 20.3 μsec $\pm$0.05 μsec, with taps available at every 1.45 μsec. A minimum delay-to-rise time ratio of 100:1 has been established for these units by incorporating specially wound toroidal inductors with Q's in excess of 300, and stabilized mica capacitors. Characteristic impedance is 470 ohms and attenuation is less than 2 db. Spurious signals are maintained below -20 db. Operating temperature range is $-55°$ to $+85°$C. Richard D. Brew & Co., Inc., Concord, N.H.

Write No. 420 in Box on Inquiry Card

Epitaxial Silicon Transistors

Texas Instruments Inc. announced the availability of two epitaxial ultra-fast silicon switching transistors which they consider to be the most advanced switching transistor ever offered in production quantities. TI stated that the devices will perform their switching function in 24 billionths of a second — more than twice as fast as any other silicon transistor. While the new devices are expected to find their greatest immediate application in electronic computers, TI believes that their potential range of usage permits them to be classified as small-signal general purpose transistors. The new transistors are priced competitively with conventional silicon switching transistors. Texas Instruments, Inc., Dallas, Tex.

Write No. 491 in Box on Inquiry Card

Coax Switches

Multi position coax switches, with BNC type connectors, are designed for 52 or 75 ohm coaxial lines. One model, a single pole, 5 position switch, provides contacts for switching to any one of five separate units such as transmitter and antennas and handles up to 350 volts rms. A second unit, a double-pole, 2 position switch, rapidly cuts equipment in and out of series connection in coaxial lines. Barker & Williamson, Inc., Bristol, Pa.

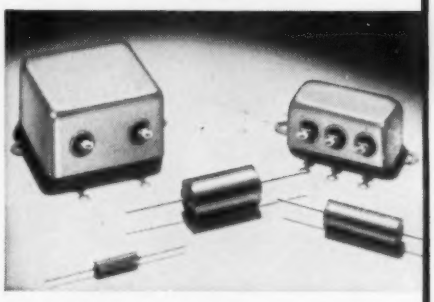
Write No. 390 in Box on Inquiry Card

Miniature Thermocouples

Low priced thermocouple assembly is said to have an adaptability which covers virtually the entire range of thermocouple temperature sensing applications. Specific performance is guaranteed to equal or surpass that of the most expensive thermocouples. Temperature measurements of any medium — gas, liquid, semi-solid, etc — can be made. Harco Labs., New Haven, Conn.

Write No. 401 in Box on Inquiry Card

for size...
stability...
service



Exceed MIL Requirements!

Available in two case styles: bathtub (TYPE AB) Metal clad miniature (tubular — TYPE AM)

the New
METALLIZED MYLAR*
CAPACITORS
by
PC

On the job, Metallized Mylar* really delivers with such outstanding characteristics as: self healing; elimination of weak dielectric areas; great reliability; excellent economy. Temperature range for operating and storage $-90°$C $+125°$C; capacitance tolerances are 1%, 2%, 5%, 10% and 20%; with low dielectric absorption and high resistance. Write today for complete information including literature with curves, all listings, technical information and illustrations.

*Dupont Polyester Film.

Plastic Capacitors, INC.
2620 N. Clybourn • Chicago 14, Illinois
DI 8-3735

"Custom PC Engineered at Production Prices!"

CIRCLE NO. 57 ON INQUIRY CARD

Federal Telephone & Radio
uses SEL-REX bright gold
to improve electronic component reliability

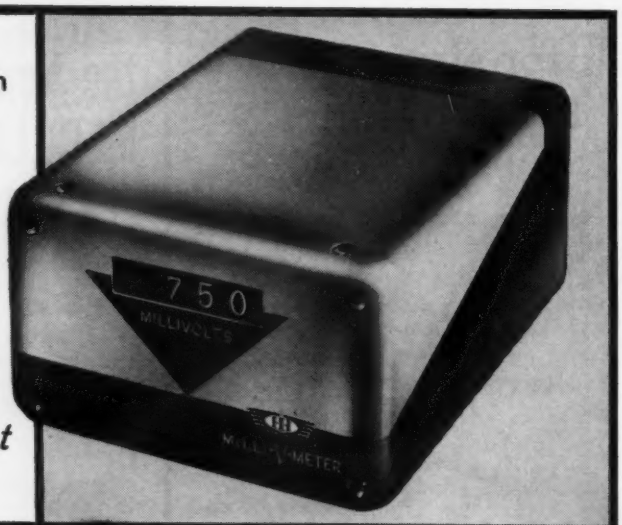
Sel-Rex Bright Gold is used on a variety of electronic parts at Federal because, to quote Mr. William F. Boyle, Chief Metallurgist, the deposits are "...fine grained and dense, giving exact duplication of the surface plated... (it) eliminates galling in sliding electrical contacts" and has "effected a tremendous saving" over previous materials and methods.

The Federal Telephone story, other case histories and technical data FREE on request.

Sel-Rex®
SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY
World's largest selling precious metal plating processes

CIRCLE NO. 56 ON INQUIRY CARD

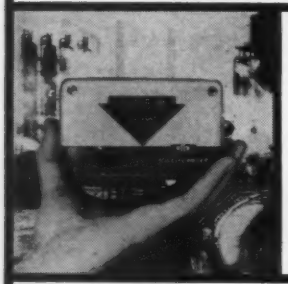
1/20th CUBIC FOOT of Dynamic Measurement



The Series BH100

MILLI-V-METER®

The instrument with the TAPE-SLIDEWIRE



for PETROLEUM, CHEMICAL, STEEL, ALUMINUM and other processing plants...

to accurately indicate

TEMPERATURE, FREQUENCY, FLOW, LEVEL, PRESSURE, R.P.M., WEIGHT, etc.

Every function of the producing plant may be measured *and controlled* with high accuracy. Ideally small and designed for uniform panel installation, the MILLI-V-METER is completely self-contained...including power supply, servo unit, slidewire and amplifier. Every measurement exhibited on the counter is a precisely (electronically) calibrated value.

1/10 the size

10 times the accuracy

of standard instruments

QUALITIES

1) Accuracy 1 part in 1000. Laboratory precision for industry or the military.
2) Compatibility with any transducer—AC or DC.
3) For strain gage, linear differential transformer, thermocouple, thermistor, resistance thermometer, pulse or variable frequency circuits or systems.
4) Operates directly from 60- or 400-cycle power as specified.

SPECIAL FEATURES

For Recording...a re-transmitting slidewire may be provided within the case.

For Controlling...switch contacts may be provided to operate control units, remote indicators, or printers.

For Computers or Telemetering...counters with decimal outputs may be added.

Produced by the makers of JETCAL® *jet engine Analyzer ...in worldwide military and airline use!*

Full information is available for the asking!

Sales-Engineering Offices:
COMPTON, CAL.
DAYTON, OHIO; WICHITA, KAN.
VALLEY STREAM, L. I., N. Y.
TORONTO, ONT. (George Kelk Ltd.)
MITCHAM, SURREY, ENGLAND
(Bryans Aeroquipment Ltd.)

HOWELL INSTRUMENTS, INC.
FORMERLY B&H INSTRUMENT CO., INC.
3479 WEST VICKERY BLVD. • FORT WORTH 7, TEXAS

CIRCLE NO. 58 ON INQUIRY CARD

NEW COMPONENTS

Signal Amplifier

Miniaturized signal amplifier, with a size of 4 cubic inches and a weight of 4.25 oz, totally utilizes low level signals and proves itself more reliable in adverse environments than larger and heavier amplifiers. The unit may be used with any resistance strain gage transducer. Potentiometers are provided to permit zero and sensitivity adjustments. The signal output of the carrier amplifier is isolated from the power supply input. Output is −0.5 to +5 volts dc, with a power requirement of 35 milliamps at 28 volts dc ±5%. Frequency response is a flat ±4% (referenced to dc) from 0-2000 cps. The amplifier is designed to operate with transducers with a rated sensitivity from 1.5 millivolts per volt to 10 millivolts per volt. Balance control is from −0.5 to +4 volts dc. Output impedance is less than 3600 ohms, and combined non-linearity and hysteresis is less than ±0.3% of full scale. Statham Instruments Inc., Los Angeles, Calif.

Write No. 334 in Box on Inquiry Card

Silicon Mesa Transistor

Transistor's 175 volt collector-base breakdown is 50 percent higher than any other silicon mesa type. It is designed to replace high voltage relays and is recommended for high voltage avalanche operation and for use in constant current generators. Unit provides 8 volt emitter-base breakdown and maximum collector capacitance of 15 mmf at 10 v. The transistor also has a high LV_{CEO} greater than 110 volts at 1ma. Alpha cuto ffis 30 megacycles and the small signal beta range is from 20 to 100. The unit can be operated in common base with a constant current characteristic to its maximum rated voltage and will switch up to 250 volts in avalanche condition. Rheem Semiconductor Corp., Mountain View, Calif.

Write No. 330 in Box on Inquiry Card

Digital Voltmeter

Use of plug-in switches speeds trouble-shooting and simplifies switch replacement, a potentially troublesome, time-consuming servicing task in stepping switch digital voltmeters. With new "finger-control" leverage bars, stepping switches can be replaced in less than a minute. Accuracy of the four-digit voltmeter is ±0.01%. Non-Linear Systems, Inc., Del Mar, Calif.

Write No. 428 in Box on Inquiry Card

DC Motor Reversing Drive

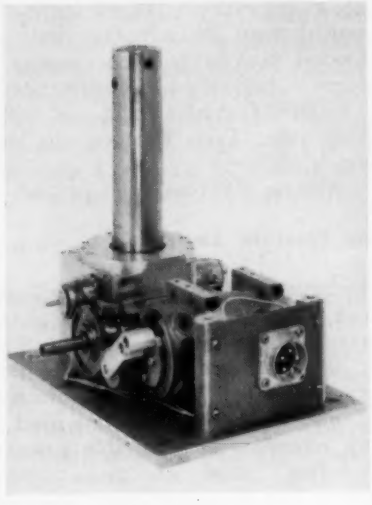
For dc shunt motors of up to 3 hp, a solid-state drive reverses direction and rotation without contactors or relays. It operates smooth and stepless with no dead-band around zero speed. Having no moving parts, units do not arc or pit, response time is negligible and contact chatter non-existent. ACF Electronics, Paramus, N. J.

Write No. 522 in Box on Inquiry Card

Size 11 Synchro

Designed for use in fuel flow instruments, hydraulic pressure indicators and torque indicators, a synchro receiver weighs 2¾ oz and has a servo type mounting. (Other mounting configurations are available). Unit also serves as either a transmitter or receiver and can be servo driven for positioning potentiometers and servo instruments. Model Engineering & Manufacturing Corp., Huntington, Ind.

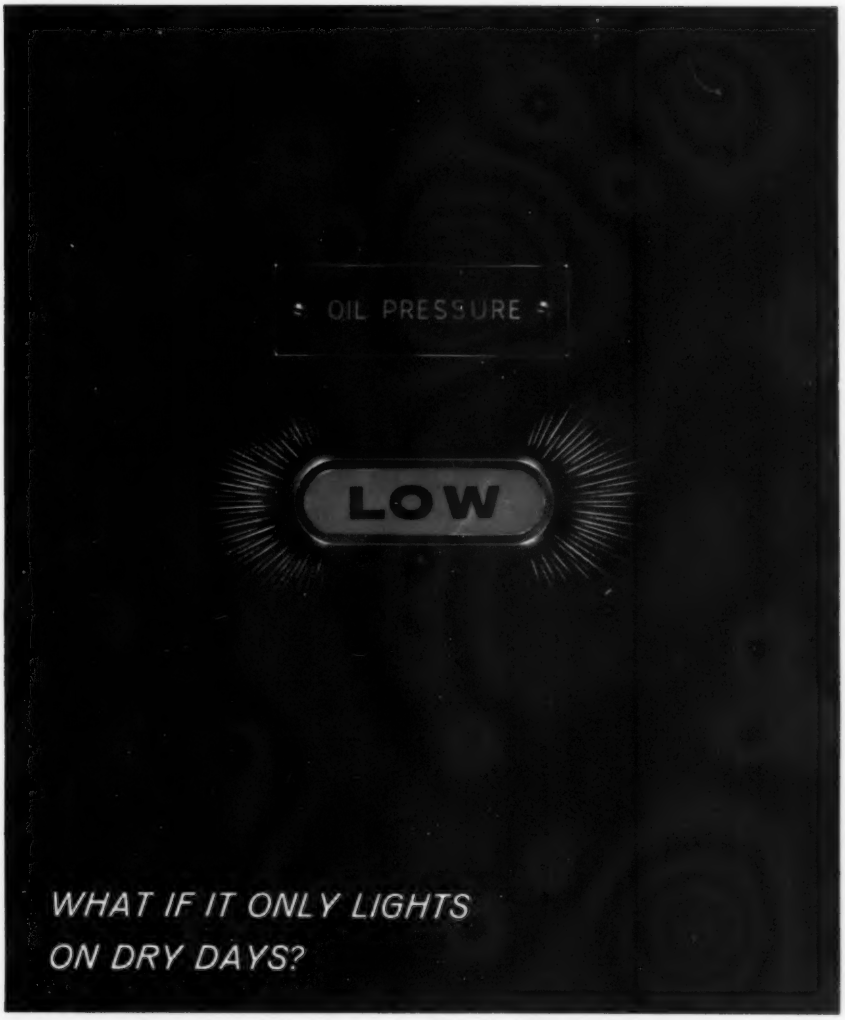
Write No. 524 in Box on Inquiry Card



Servo Actuator

Shown above is a breadboard demonrator model of American Elecronics, Inc.'s new 8-millisecond response electric servo actuator for the control of flight surfaces of missiles. Utilizing a constant speed miniaturized motor as its source of motion, and a new clutch, developed by the L. A. Company, to give left or right action, each flight control surface is direcaly connected to its own actuator. Weight savings of as much as 50 percent over hydraulic syseems are clained, in addition to the total eliminations of piping, valves, filers, linkages, accumulators and other plumbing accessories. Shelf life without maintenance is infinite, since there are no seals, fluids or other elements in the actuation system that can deteriorate.

Write No. 371 in Box on Inquiry Card



Pressure switches that only sound the alarm on dry days are small comfort when the weather gets soggy.

The *one* way to be sure about a pressure switch is to test it through the whole range of operating requirements . . . not just at 0% humidity or just at room temperature.

Take Model 6547 shown at right which serves in many ways . . . cabin pressure alarm, landing gear position signal, electronic equipment operation, acting parallel to an altimeter. This pressure switch has a calibration accuracy of 20 mm Hg from −65° F to 250° F, 0 to 100% humidity, with an actuation range of 2,000 to 20,000 and 15,000 to 70,000 feet. It weighs only 5½ ounces.

Do what we did. Get one and run it through six weeks of testing over the *entire* range of your operating requirements.

Or you can save yourself six weeks by examining our own test data on a full line of pressure switches for the type that meets your needs best. Call Mr. Charles Colt at Consolidated Controls, Bethel, Conn. Phone Pioneer 3-6721, DDD Code 203.

Inches of Water to Hundreds of Atmospheres

Model 6547 shown above is one of more than 300 pressure switches available from Consolidated Controls for missile, aircraft and nuclear applications. Working pressures range from 10" of water to 10,000 psi at ambient temperatures from −65°F to 1000°F. Standard models for

- high vibration
- differential pressures
- hydraulic
- miniaturized applications
- high temperature

CONSOLIDATED CONTROLS CORPORATION

A Member of The Condec Group

BETHEL, CONNECTICUT
INGLEWOOD, CALIFORNIA

CIRCLE NO. 59 ON INQUIRY CARD

SETTING THE PACE

by
Arthur L. Fitch
President
Pace
Controls
Corp.

ONE WAY TO MEET THE TREND TOWARD DIGITAL CONTROL

Pace Control's reason for being is based on a firm belief in the future of the automatic control industry. As we see it, our function is to provide means for accomplishing complex operations, efficiently and accurately, where manual or semi-manual skills are not adequate — or may not even be possible. We see it as our function, too, to provide a release from the tedium of repetitive operations. This is our governing philosophy and the reason behind this series of articles I've called "Setting The Pace".

Concurrent with our approach toward the control industry, we recognize that the demands of this era of industrial revolution for technical apparatus — and its control — are compounding themselves with each passing year.

Already, a decided trend toward the digital approach in the electronics industry is evidenced in the swing from devices that have been analog toward conversion to digital.

This would include just about everything from computers to voltmeters. What's the explanation for this trend? It could be found quite possibly in the mounting demand for versatility, reliability and simplicity.

Now, if automatic control, particularly electronics, is to enjoy a boundless future, — and if the approach to electronic control devices is to lean more heavily on the digital approach, doesn't it seem logical to conclude that digital control, indeed, is a business with a future? We think so.

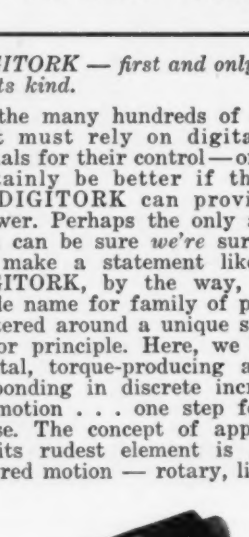
And it follows, with equal logic, that if the trend is toward digital electronics in the form of computers, programmers, read-in and read-out devices and a myriad of other electronic devices, it can be safely assumed that digital apparatus will do the work.

To a large extent, without DIGITORK (which we'll tell you about shortly), this just isn't possible. Even now, a completely digital control system will eventually terminate in digital to analog conversion to do work with analog devices.

We believe that the *completely* digital approach cannot end at the input. Rather, it must eventually be carried through to the output — and where necessary — again back to the input for checking reference.

DIGITORK — first and only motor of its kind.

Of the many hundreds of devices that must rely on digital type signals for their control — or would certainly be better if they did — DIGITORK can provide the answer. Perhaps the only answer. You can be sure *we're* sure when we make a statement like that! DIGITORK, by the way, is our trade name for family of products centered around a unique stepping motor principle. Here, we have a digital, torque-producing actuator responding in discrete increments of motion . . . one step for each pulse. The concept of application in its rudest element is . . . a desired motion — rotary, linear or



other — may be accurately controlled by the *number* of pulse signals furnished. The speed of the motion may be accurately controlled by the *rate* at which the signals are delivered to the control. Certainly, there's much more to tell about DIGITORK than this, but we're getting too close to the bottom of the page. We expect you'll want to learn the whole exciting story, so write in and we'll have it on its way to you by return mail.

In any case, with acceptance of the DIGITORK principle gaining momentum at an encouraging rate, we at Pace Controls foresee a most promising future. As we see it . . .

DIGITORK is truly...Setting The Pace!

PACE CONTROLS CORP.

NEEDHAM HEIGHTS 94, MASSACHUSETTS
Hillcrest 4-8844

CIRCLE NO. 60 ON INQUIRY CARD

NEW COMPONENTS

Magnetically Controlled Relay

Designed specifically for bias protection in airborne radar systems, a magnetic amplifier controlled relay meets environmental conditions in any combination without contact chatter. It is useful in any system where loss of bias voltage results in a chain reaction-type catastrophic failure. Power required: 102 volts at 380-420 cps. Control power: 105 vc at 7 ma max. Relay contact rating: DPDT 115v rms at 2 amps. Relay pull-in voltage: 95v max. Dropout voltage: 85v min. Temperature range: −54 to +115°C. Wahlgreen Magnetics, Monrovia, Calif.

Write No. 517 in Box on Inquiry Card

Pressure Transducer

Providing an overall accuracy to within ±0.1%, an integrally packaged 1-100 pressure pick-up produces a linear direct current output voltage. Unit is temperature controlled at 125°F. Input: 105 to 125, VAC, 60 cycle. Instrument may be left energized for extended periods without damage or change in calibration. Pressure ranges: 0.5 to 0-5000 psid or psig and 0-5 to 0-5000 psia. Tavis Engineering, Monrovia, Calif.

Write No. 311 in Box on Inquiry Card

Low Pressure Switch

Weighing less than 22 oz, explosion proof switches may be used for gauge, vacuum or differential service. Electric element is enclosed in an all-metal hermetically sealed case. With differential unit, liquid media can be used for both reference and variable pressure. Operating range of gauge switch model: 1 to 30 in H_2O; vacuum model: −30 in H_2O increasing and 0 to 27 in H_2O decreasing. Custom Component Switches, Inc., Burbank, Calif.

Write No. 550 in Box on Inquiry Card

Digital Control Module

Reset transfer control module contains three independent multivibrators. Each adjusts to a delay period ranging three to 30 microsec. By utilizing jumpers which are present on the card, the three units may be series connected. Inverted and non-inverted outputs are available with the latter providing up to 750 ma of drive current capability. A pulse amplifier, also included, connects to any of the three multivibrators providing a pulse at the conclusion of the delay period. Navigation Computer Corp., Philadelphia, Pa.

Write No. 416 in Box on Inquiry Card

Constant Voltage Transformers

Static-magnetic voltage regulating transformers maintain output voltages within one percent despite input voltage fluctuations up to 15 percent. Regulation is instantaneous, continuous and completely automatic. Operating on principles of ferroresonance, the units have no tubes, moving parts or separate saturable reactors. Design is such that virtually any output voltage/current combination can be obtained from only a few basic lamination configurations and windings. Outputs may thus be custom made to individual specifications, usually at low cost even in relatively small quantities. Neshaminy Transformer Corp., Neshaminy, Pa.

Write No. 344 in Box on Inquiry Card

12" Memory Drums

A 50 track, 300 kc magnetic memory drum operates at 3,600 rpm (nominal) with a capacity of 133 bits per inch. With cover, it measures 17" in dia by 12" high and weighs 80 lbs. It utilizes a 60 cycle, single-phase, 110 volt motor for either 3,600 or 1,800 rpm (nominal). Built to mil specs, the drum contains hermetically sealed connectors and a heavy-duty, bolt-down cover to withstand extreme temperature changes and adverse environments. Digital Development Corp., La Jolla, Calif.

Write No. 349 in Box on Inquiry Card

Centrifugal Fans

Designed for cooling and pressurizing requirements in the electronic and control fields, with scroll widths ranging from 3⅞" to 9¼", a series of compact, single inlet, single wheel centrifugal fans deliver air from 45 to 324 cfm over a wide pressure range. They can be provided with special mounting brackets and filter cabinets to simplify adaption to custom cabinets. Robbins & Myers, Inc., Springfield, Ohio.

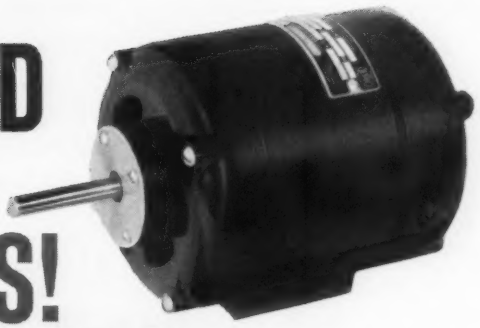
Write No. 521 in Box on Inquiry Card

Synchro Size 11 Encoders

Miniaturized to 1" in dia, an eight-bit shaft angle encoder weighs 1.8 oz, including silicon isolation diodes and 15" of wire leads. Double brush in V pattern scans the coding disk to eliminate transition ambiguity. Silicon switching diodes are internally wired in series with each brush output for selection logic time sharing. Resolution is one part in 256, equal to 1.4 degrees of shaft rotation, with an absolute conversion error of less than ±¼ of the least significant digit or 21 minutes of arc. Litton Systems, Inc., Woodland Hills, Calif.

Write No. 514 in Box on Inquiry Card

MACHINED MATING SURFACES!



HOWARD

UNIVERSAL & DC
29-500 MOTOR
1/12 TO 1/4 H.P.

The Ultimate in Universal Motor Quality— at Lowest Cost Available!

So fine a motor, all mating surfaces are **machined**—not die-cut—for closest possible tolerance! Assures uniformity of air gap for minimum cogging, uniform output. For communications, hospital, dental, metering and hydraulic pump equipment, computors and other applications.

Write today for complete details!

DIAM. 3¼" **LENGTH** 4¹¹⁄₁₆" to 5¹⁵⁄₁₆"
H.P. Continuous:
Series—1/6 @ 10,000 RPM
Shunt or Compound—1/12
Intermittent:
Series—1/4 @ 10,000 RPM
Shunt or Compound—1/6
SPEED:
No Load: Series—15,000 RPM
Shunt or Compound—12,000 RPM
Full Load: Series—3,000 to 10,000 RPM
Shunt or Compound—1,000 to 10,000 RPM
VOLTAGES:
Series—6 to 250V AC/DC
Shunt or Compound—6 to 230V DC

Divisions: Electric Motor Corp. Cyclohm Motor Corp. Loyd Scruggs Co. Racine Electric Products

HOWARD INDUSTRIES, INC. • 1796 State Street • Racine, Wisconsin

CIRCLE NO. 62 ON INQUIRY CARD

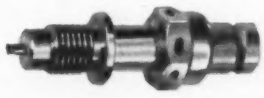
ELECTRO
Custom Pickups

SOLVE TOUGH CONTROL PROBLEMS

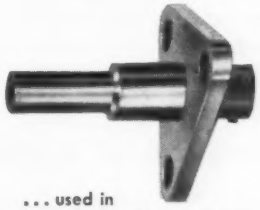
These are only a few of 100's of designs manufactured for special and critical applications. EPL Magnetic Pickups convert mechanical energy to voltage/frequency in proportion to speed. No physical contact or electrical power needed. They weigh as little as 2/10 oz. and never wear out.

... positions antenna in air-borne Doppler Navigation systems

... APU overspeed safety shut-off transducer requires no external power source on military aircraft



... senses overspeed in turbines of jet airliners



... used in classified missile applications.

Write for Bulletin CMP-50 and Name of Your EPL Representative

ELECTRO PRODUCTS LABORATORIES
4501-F Ravenswood, Chicago 40
Canada: Atlas Instrument Corp., Ltd., Toronto, Ontario

CIRCLE NO. 61 ON INQUIRY CARD

Summer Institute at Tufts University
for
TECHNICAL WRITERS AND PUBLISHERS

31 July to 11 August 1961

Director: Dr. Paul H. Flint, Professor of English
and Dean of the Graduate School of Arts and Sciences.

ESTABLISHED IN 1956 as the Workshop in Technical Writing, The Institute is given with the cooperation of leading publications specialists in the Greater Boston area, most of them senior members of the Society of Technical Writers and Publishers who have participated in the development of the Institute over several years. This year the Institute will focus on the problems of

PUBLICATIONS MANAGEMENT

FIRST WEEK

"Selling" the publications department — Organizing the publications department — Recruiting, hiring, training — Contractual requirements: specifications — Production and printing—Proposals — Estimating time and costs.

SECOND WEEK

Subcontracting and monitoring — Illustrations — The writer or publisher's own professional articles and oral presentations — The future of technical communication — Case histories — Critiques of projects brought to the Institute — Individual consultation with Institute staff.

Sessions: Two full weeks: Some evening meetings. No Institute sessions scheduled after noon on Wednesday 2 August and Friday 11 August.

Fee: $160 for both weeks; $100 for the first week.

Dormitory Accommodations: For individuals, couples, and couples with children at $13 a week per person.

Meals: In the University cafeteria for Institute members and their guests at moderate prices.

Location: Nearby are the beautiful beaches of Boston's North and South Shores; Cape Cod; and the mountains of Vermont and New Hampshire. The center of Boston is twenty minutes from the campus.

Address Inquiries to:

Summer Institute for Technical Writers and Publishers
8 North Hall, Tufts University
Medford 55, Massachusetts

NEW COMPONENTS

Tiny Reed Switch

"Ten to the inch" magnetic reed switch, believed to be the world's smallest, makes possible the use of miniature relays and cross-points in printed circuit boards or modules based on a 0.1" center. Contact surfaces are a low-resistance, fully magnetic alloy of gold, nickel and iron. External leads are adaptable to both welding and soldering, and may be bent or cut for printed board applications. Life expectancy, at maximum rating, is 3,000,000 operations. Gordos Corp., Bloomfield, N.J.

Write No. 327 in Box on Inquiry Card

Switching Transistors

Combining the advantages of mesa construction with epitaxial techniques, Sylvania Electric Prods., Inc. has come up with the "fastest silicon switching transistor." This development follows their last month's announcement of the fastest germanium switching transistor. The new silicon small signal device has a maximum turn-on time of 16 nanoseconds and turn-off time of 30 nanoseconds giving a total switching time of only 46 in a 2N706A test circuit with standard conditions.

Write No. 425 in Box on Inquiry Card

High Power Switching

Prototype quantities of new semiconductor switching devices Trinistor controlled rectifiers are now available from Westinghouse Electric Corp. The Trinistor is a three terminal silicon device which can be used to control large blocks of power. Its characteristics are similar to those of a thyratron, in that the device will block voltage in the forward direction below a critical breakover voltage. However, by exceeding the critical breakover voltage or applying a proper gate signal, the device will rapidly switch to the conducting state. Units are best suited for high power applications at up to 300 volts and currents up to 50 amps. Switching time is 600 millimicroseconds with peak reverse voltages of 60 to 360 volts. Wide range of control and switching applications include: converters, variable frequency generators, motor control, voltage regulation, replacement of magnetic amplifiers, high power modulation, inverters, replacement of thyratrons, and many others. Westinghouse Elec. Corp., Youngwood, Pa.

Write No. 427 in Box on Inquiry Card

Mars products are available at better engineering and drafting material suppliers everywhere

Duralar:

WON'T SMEAR ON MYLAR - ERASES ON MYLAR

Specifically designed to work perfectly on matte-surface drafting film of Mylar®, Duralar is the newest in the complete line of Mars fine drafting products. All are imported from West Germany and are made to meet the highest professional standards. Shown: Mars-Lumograph Duralar pencil and lead—available in five special degrees, K1 to K5; Mars-Duralar Technico with adjustable Duralar degree indicator; Duralar eraser.

®T.M. for duPONT's Polyester film.

the pencil that's as good as it looks

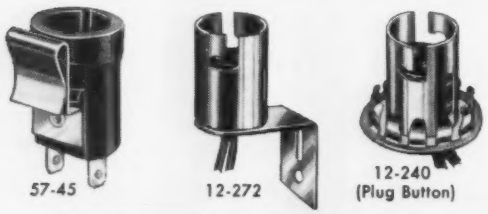
MARS

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

CIRCLE NO. 63 ON INQUIRY CARD

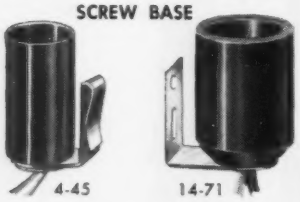
The COMPLETE LINE of
SOCKETS and LAMPHOLDERS
For Small Lamps For Every Need
LEECRAFT
(Illust. approx. 60% actual size)

DOUBLE CONTACT CANDELABRA BAYONET



MINIATURE BAYONET

CANDELABRA INTERMEDIATE
SCREW BASE



WIRE TERMINATIONS
A large variety of Solderless Terminals - such as Quick Connect, Ring, Flag, Spade, etc.- can be furnished with wire lead assemblies.

LAMPS
Order complete with lamp to assure your receiving a correct assembly, ready for immediate use.

SPECIALTIES
Besides thousands of standard sockets, we also offer excellent modern facilities for the manufacture of special assemblies, such as:
Multiple Sockets • Non-Ferrous Sockets
Printed Circuit Sockets • Neon Units
Wiring Harnesses • Wire Lead Assemblies
Grounded Sockets • D.C. Indexing
Plug Button Units • Lamp Shields
Electronic Assemblies • Sub-Assemblies
Cord and Plug Assemblies

SAMPLES ON REQUEST AT ONCE—NO CHARGE • ASK FOR CATALOG LD

LEECRAFT MFG. CO., Inc.
58 Greene St., New York 12, N.Y.
WOrth 6-2855 • TWX #NY 1-3866

CIRCLE NO. 65 ON INQUIRY CARD

Here's How Haveg Solved the Problem...
with HAVELEX®
PRECISION MOLDED RIGID INORGANIC INSULATING MATERIAL

This miniature switch base molded with Havelex, contains four different stainless steel inserts with precious metal plating. Three inserts (which include #0-80 male threads) go all the way through the mold and provide precision mountings on both sides for assembly. The #0-80 female threaded insert is designed to protrude from one face and is approached by a molded counterbore from the other. Mold is designed to accommodate alternate terminal inserts when unthreaded models are required.

Haveg engineers recommended Havelex for this particular molding because of its combination of properties. Completely inorganic, with metal inserts integrally molded in place. Precision tolerances with faithful reproduction from part to part. Heat resistance for continuous operation in excess of 700°F.

Haveg engineers will be happy to work with you on your particular project—to help you "Keep ahead with Haveg." *Remember*—Havelex offers all of these unique features: **Dimensional Stability • 1000°F. Continuous Temperature Resistance • Dielectric Strength • Mechanical Strength • Low Loss, Low Power Factor • Arc Resistance • No Moisture Absorption • Integrally Molded Metal Inserts • Hermetically Sealed Inserts.**

Keep Ahead with HAVEG.
FIRST IN *Engineered* PLASTICS

TAUNTON DIVISION
HAVEG INDUSTRIES, INC.
336 Weir Street • Taunton, Massachusetts
Telephone VAndyke 4-4011

CIRCLE NO. 64 ON INQUIRY CARD

NEW COMPONENTS

Delay Memory Drum

Basic to a delay/memory system is a 20-channel magnetic oxide drum with storage densities up to 9000 discrete information bits per channel. Recording heads adjust circumferentially to provide continuously variable delays of from two to 60 sec. System has been successfully adapted in continuous process control where flaw detection is recorded and rejection devices are keyed or actuated without interrupting a continuous process. Other applications include material sorting and handling quality control alarms. Electron-Ohio, Inc., Solon, Ohio

Write No. 528 in Box on Inquiry Card

SCR Power Supply

Available from stock, general purpose 30 amp dc supply incorporates silicon controlled rectifiers to provide ±0.5% voltage regulation and 1% rms ripple. Operating from a 115 volt, single phase, 60 cycle power source, the unit delivers 50 amps for one minute or 30 amps continuous duty, with a voltage adjustment range of 2 to 36 volt. Christie Electric Corp., Los Angeles, Calif.

Write No. 308 in Box on Inquiry Card

Long-Life Relays

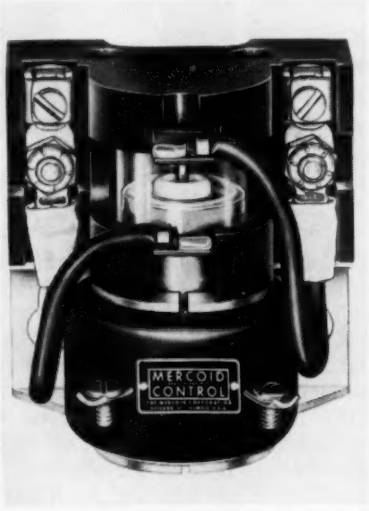
Slightly larger than one cubic inch, 4 pot relays operate under a light load in excess of 100 million cycles with less than 5% variation in electrical characteristics. Units are rated for loads ranging from dry circuit up to 3 amps at 30 volts dc or 115 volts ac resistive. Contact arrangements of 4 Form C and 2 Form Z are available. Coil operating voltages range from 6 to 110 volts dc. Operating 0.5 watt minimum power, 0.9 watt nominal and 2.0 watts maximum at 25°C, the relays have time values of 15 milliseconds maximum pull-in, 5 milliseconds maximum drop-out, 3 milliseconds maximum transfer time on pull-in and approximately 1 millisecond transfer time on drop-out. Potter & Brumfield, Princeton, Ind.

Write No. 316 in Box on Inquiry Card

Ferrite Storage Cores

Without current or temperature compensation, ferrite storage cores operate over a temperature range of —55 to +100°C. These 0.050" units have been designed for coincident current memory operation and are now available in experimental quantities. Ampex Computer Prod. Co., Culver City, Calif.

Write No. 305 in Box on Inquiry Card



Mercury Relay

New relay design provides a large surface area of mercury at contact level for longer life at maximum loads. Same plunger action is obtained for all normal line voltage fluctuations, assuring uniform contact performance. Design provides short radial conducting path between electrodes. A center electrode is always in contact with mercury in a ceramic cup supported by a movable plunger. An annular second electrode is always immersed in the main body of mercury near contact level. Contact is made by plunger action to unite the two bodies of mercury. The Mercoid Corp., Chicago, Ill.

Write No. 312 in Box on Inquiry Card

Digital Modules

Modules allow the assembly of complex electronic digital systems with a minimum of original circuit design. Burroughs Corp., Electronic Tube Div. announces the availability of their basic electronic components, Beam-X switches, in a new modular design to perform the functions of counting, distributing, multiplexing, scanning and decoding. A "universal module" can be used for counting, distributing, multiplexing, and scanning applications. All functions can be performed by merely reconnecting the input and output terminals of the module. Called the DC-112, it utilizes the general purpose Beam-X switch in conjunction with a frame grid pentode tube which performs the coupling function between successive modules.

Write No. 317 in Box on Inquiry Card

Wiley BOOKS

MAGNETIC CONTROL OF INDUSTRIAL MOTORS
Three vols. By G. W. HEUMANN, General Electric Co. Controllers for A-C and D-C motors are analyzed, and each type is given full treatment in conjunction with its controllers. **Part I:** A-C Control Devices and Assemblies. 1961. Approx. 312 pages. $9.00. **Part II:** A-C Motor Controllers. 1961. 334 pages. $9.00. **Part III:** D-C Motor Controllers. In Press

SYSTEMS: RESEARCH AND DESIGN
Edited by D. P. ECKMAN, Case Institute of Technology. Clarifies the philosophy of systems engineering, stressing the interdisciplinary approach to formulation of complex systems. 1961. Approx. 328 pages. Prob. $9.00

ESSENTIALS OF DIELECTROMAGNETIC ENGINEERING
By H. M. SCHLICKE, Allen-Bradley Co. Applies the scientific approach to practical engineering problems of modern electronic ceramics. 1961. 242 pages. $9.50

TRANSACTIONS OF THE SYMPOSIUM ON ELECTRODE PROCESSES
Edited by ERNEST YEAGER, Western Reserve University. Ready in July. Approx. 484 pages. Prob. $20.00

HIGH-FREQUENCY MAGNETIC MATERIALS
Their Characteristics and Principal Applications. By W. J. POLYDOROFF, Consultant. Covers all ferromagnetic materials, including measurements and applications at high frequency. 1960. 221 pages. $9.00

COUPLED MODE AND PARAMETRIC ELECTRONICS
By W. H. LOUISELL, Bell Laboratories. Applies the coupled mode approach to space charge waves, parametric amplifiers and related devices. 1960. 268 pages. $11.50

DIGITAL APPLICATIONS OF MAGNETIC DEVICES
Edited by A. J. MEYERHOFF, Burrows Corp. Electrical, logical and system design for building digital systems using the toroidal magnet or magnetic core as the basic circuit element. 1960. 604 pages. $14.00

THE DYNAMIC BEHAVIOR OF THERMOELECTRIC DEVICES
By P. E. GRAY, M.I.T. Investigates small-signal dynamic behavior of thermoelectric devices (computes device response in either time- or frequency-domain). An M.I.T. Press Research Monograph. 1960. 136 pages. $3.50

THE THEORY AND DESIGN OF INDUCTANCE COILS
By V. G. WELSBY, Birmingham Univ. Covers principles for those interested in practical results rather than elegance of treatment. 1960. 232 pages. $6.00

ELECTRONIC EQUIPMENT RELIABILITY
By G. W. A. DUMMER and N. B. GRIFFIN, Royal Radar Establishment. How equipment reacts under different environments, what tests to use, and best constructional methods. 1961. 274 pages. $7.50

Send now for your on-approval copies

JOHN WILEY & SONS, Inc.
440 Park Avenue South, New York 16, N. Y.

CIRCLE NO. 55 ON INQUIRY CARD

POTPOURRI

For some mysterious reason, this month's collection of new component announcements, covered an unusually high number of new potentiometers. In order to cover them all (and to avoid the problem of trying to think of different titles for each), we combined them here.

Rated at 1 watt up to 70°C, Dale Electronic's new trimmer has a square (0.500" x 0.190" x 0.500") configuration. Operating in the −65 to 150°C range, it is available in nine standard resistances from 100 to 50K ohms. Standard tolerance is 5%. All fixed connections are of welded construction and the 25-turn pot is sealed to provide protection against moisture and potting compounds.

Write No. 359 in Box on Inquiry Card

Of particular advantage, when stacking printed circuit boards together, is the height-off-board dimension (0.195") of Daystrom's Model 385 1/2 square trimming potentiometer. Resistance values run from 10 ohms to 50 kilohms over a temperature range of −55 to +200°C. Resolution at 50 kilohms is given as 0.086%.

Write No. 360 in Box on Inquiry Card

Markite Corp. reports that their new rectangular linear motion potentiometers are distinguished from conventional units in that the resistance element embodies two electrically isolated solid raised tracks of conductive plastic integrally co-molded, together with taps and terminals, to an insulator base of high temperature phenolic resin of matched thermal expansion coefficient. The potentiometers exhibit a low electrical noise and resist 70g vibration at 5 to 2000 cps as well as shock loading in excess of 100g without malfunction. Offering independent linearities of ±0.5% or better, the new units are available with element resistances ranging from 250 to 50K ohms.

Write No. 383 in Box on Inquiry Card

High reliability potentiometer with glass-sealed terminals for high temperature operation, from Clarostat Mfg. Co., is a wire-wound, 2.0 watt unit available in resistance up to 100,000 ohms. Linearity is of the order of 2%. Unit derates to zero at 150°C and meets mil specs.

Write No. 367 in Box on Inquiry Card

Specifically designed for potting, two micro-miniature trimmer controls, developed by Minelco, Holbrook, Mass., are available in resistance values from 100 ohms to 10K. Both the stud-mounted and lead-mounted types have a diameter and a body length of ¼ inch. The potting compound penetrates the pot to fix the wiper in any pre-adjusted position. End resistance is less than 1%; resolution, 0.25% to 1% depending upon resistance value; power rating, 0.25 watt and weight is 0.02 oz.

Write No. 370 in Box on Inquiry Card

Unitized rotor design yields smooth operation in Duncan Electronics' new multi-turn potentiometer series. Offered in both three and 10 turn sizes, with either bushing or servo type mountings, the 1¾" diameter units exceed all applicable mil specs. Standard linearity tolerance is 0.1% in the ten turn and 0.2% in the three turn.

Write No. 380 in Box on Inquiry Card

Linearity of ±0.005% is claimed for Litton Industries' precision multi-turn units. One model measures two inches in diameter and another measures three inches. Both accommodate taps in any location and have capability of relatively high-accuracy load compensation and high power dissipation.

Write No. 382 in Box on Inquiry Card

Techno-Components Corp. introduces a series of micro-size trimming pots measuring 0.375 x 0.375 x 0.185. Standard resistances are in the range of 10 ohms to 35K and resistance tolerance is 5%. Power rating is ¾ watt at 50°C, derating to zero at 150°C. Special features include an "O" ring seal on the adjustment screw and printed circuit models with standard 0.100 pin spacing.

Write No. 386 in Box on Inquiry Card

In announcing the production of a semi-precision (one to five percent linearity) potentiometer, Reon Resistor Corp.'s president, Leon Resnicow, stated, "Heretofore, potentiometers with a one per cent linearity were not available at reasonable cost. Users had to purchase a high precision potentiometer at a cost of from $30 to $100. Less expensive carbon-type potentiometers could not meet accuracy requirements needed for applications in analog computers and high accuracy control systems." Reon Resistor's new unit, basically a composition type pot, is priced at about $10. Use of precious metal contacts and sleeve and high accuracy ball bearings contributes to its performance.

Write No. 385 in Box on Inquiry Card

Linear translatory unit, by Lido Transducers, has all elements enclosed within a rugged, one-piece aluminum housing which is "O" ring sealed. Unit meets military environmental requirements for shock, temperature, vibration and acceleration. Resolution is 0.1% full scale and linearity is 0.2% full scale throughout 250,000 operating cycles.

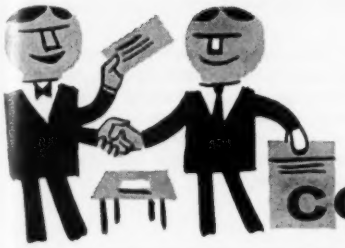
Write No. 387 in Box on Inquiry Card

Carbon version of Bourns' ¾" Trimpot features a high temperature carbon deposited on an inert and moisture-proof ceramic base providing temperature and moisture stability said to be unequalled by other carbon pots. Maximum operating temperature is 150°C. Standoffs prevent moisture trap between the base of the unit and a printed circuit board.

Write No. 396 in Box on Inquiry Card

CTS Corp. offers a low cost compact trimmer with 25 turn lead screw and clutch stops designed for printed circuit boards requiring an extremely stable resistance element but not full military specs. Resistance element performance characteristics equal or exceed Mil-R-94B characteristic Y. Contact mechanism has long spring arms for ample range and uniform pressure. Power rating is 0.2 watt at 70°C.

Write No. 395 in Box on Inquiry Card



CONTRACTS

Eliminating the conventional "soft" response usually associated with gas actuators, Weston Hydraulics of Van Nuys, Calif., has come up with a hot gas servovalve which resulted in a contract from the U. S. Army for the new Mauler Missile. As part of the flight control system, this Weston servo uses hot gases expended by a solid propellant cartridge to power the unit. Principal advantage of this new system, according to Fred O. Hosterman, Pres. of Weston, is that it retains the desirable performance characteristics of a hydraulic control system (fast forward response and positive reverse stiffness), yet operates far beyond the environmental limits of hydraulics. The system has only three basic components – gas actuator for either hot or cold gases, servo valve, and a feedback system with an exclusive mixing network. By eliminating pumps and pump drives, the servo saves more than 50% of the weight of a comparable hydraulic system. With fewer and less complex components and since no elastomeric seals are used, storage life and reliability are increased.

To establish evaluation techniques and methods for latest thermal design advances in airborne electronic equipment, Motorola's Military Electronics Div. is conducting a study under a contract to the Navy Bureau of Weapons. The first milestone was reached this month with a preliminary draft of a proposed military specification incorporating recommended design evaluation techniques. The second phase, just launched, will include tests of representative equipment. Results of the test phase, together with feedback from the initial study phase, will then be combined to establish the actual techniques and methods. The penalty imposed by elaborate cooling provisions – increased size, weight and power requirements – has long been a problem. Much work has been done, but to date, very little information exists as to their effectiveness. Establishment of standards by which their actual value can be measured is the prime objective of the study.

Advanced navigational systems for NATO military aircraft will be developed by Bendix under one of two contracts recently awarded to the company. The integrated systems, which involve $12 million, will combine two advanced developments, according to Theodore Voorhees, general manager of Bendix International. These developments, he explained, are the position-and-homing indicator, or PHI, and the Doppler radar system, both developed by Bendix. The second contract, announced by Bendix, is a $17,260,000 award to develop the communications system for Project Advent. According to R. J. Sandstrom, division general manager, Project Advent's objective is to demonstrate the feasibility of a microwave communications satellite that would operate in a 24-hour synchronous equatorial orbit, receiving and amplifying radio signals and retransmitting them to ground stations. It will mark a new era in global communications, he said.

BRIEFLY:

Aircraft components:	$1.3 million to Bowmar Instrument Corp., Fort Wayne, Ind., from NATO.
Missile guidance radar:	$33,400,000 to Sperry Gyroscope Co., Great Neck, N. Y., for Navy's Terrier.
Communication and Navigation systems:	$2 million to ITT Federal Laboratories, Nutley, N. J., from Navy Bureau of Ships.
Fire control systems:	$20 million more (total $54 million) to G.E.'s Ordnance Dept. for Polaris.
Field communications systems:	$1,633,410 to Specialty Electronics Dev. Corp., Syosset, N. Y., from U. S. Marines.

DEE PRINTED CIRCUIT SOLDER POTS

Proven design with precise controls. Mechanical type dial thermometers to indicate solder temperature. Hydraulic thermostats. Walls and bottom of the solder cavities are smooth and free of all obstructions.

Temperature range 300° to 600° F. Temperature swing ±2°. Wide variety of sizes to eight feet long. All voltages.

Send for bulletin.

DEE ELECTRIC COMPANY

Dept. ED, 1708 W. Belmont Ave.,

Chicago 13, Illinois

CIRCLE NO. 69 ON INQUIRY CARD

SECON PRECISION

POTENTIOMETER

Wire

from 37 to over 600 ohms per cmf

Secon can provide the exact precious metal potentiometer winding alloy for your requirements . . .

- **Low temperature coefficient of resistance.**
- **High tensile strength.**
- **Low noise.**
- **Supplied bare or enameled.**
- **Long life.**

For more information please write today to Secon Metals Corporation, 7 Intervale Street, White Plains, N. Y. (WHite Plains 9-4757).

SECON METALS

RELIABLE WIRE FOR THE HEART OF YOUR COMPONENT

CIRCLE NO. 68 ON INQUIRY CARD

For Your Literature File

NEW CATALOGS

Most of these catalogs contain complete specs, mounting configurations and other important details associated with the application of the products described. For your free copy of the catalogs listed on this page, enter the appropriate number of the item on the Inquiry Card.

Telemetering Switch 968

Tiny switch is said to pack more performance in its compact frame than is available in any similar switch today. Eight oz. switch provides various combinations of circuitry up to a maximum of 5 poles with 90 channels per pole. Booklet explains how the highly miniaturized construction minimizes brush velocity thus extending useful operating life. (6 pp). Electro-Tec Corp., So. Hackensack, N.J.

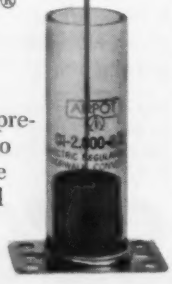
Metal-Cased Switches 682

Details on new horsepower-rated series of heavy-duty metal-cased switches and a double-break type switch are given. Listings include limit switches, safety switches, and aircraft switches. Data on bases, circuit arrangements, and Nema standard denitions of precision snap-acting switch terms are also included as well as helpful section on how to choose the switch best suited to requirements. (16 pp). The W. L. Maxson Corp., Wallingford, Conn.

When the
UNPREDICTABLE
happens

• • • the kind that creeps into the performance of newly completed systems. (Excess vibration here — slight time delay or damping needed there. Or perhaps stability doesn't match the data projected on paper.) To counter these variations, many of our customers have found the AIRPOT® an inexpensive problem solver.

AIRPOT is an air-damping dashpot; precisely constructed to operate within close tolerances. Its small size will rarely disturb a system's basic design.



To learn more about the AIRPOT, contact us at:

ELECTRIC REGULATOR CORPORATION
NORWALK, CONNECTICUT
"leaders in automatic control and regulation"

CIRCLE NO. 70 ON INQUIRY CARD

Voltage Comparators 990

A problem-solution section showing how to design complete go/no-go testing systems and how to select the correct voltage comparator or comparison amplifier for numerous applications appears in a catalog that describes transistorized voltage comparators. Instruments are said to have the accuracy, speed and reliability of quality digital volt-meters. (6 pp) Non-Linear Systems, Inc., Del Mar, Calif.

Flight Controls 986

Descriptions of 101 electronic and electromechanical devices and systems developed for aircraft and missiles are given. Included are environmental controls, flight and propulsion controls, temperature controls, and accessory components and systems. Performance characteristics and basic specs are presented for solid-state controllers, regulators and servo amplifiers; valves and actuators, and specialized transducers, including wire-wound temperature sensors. Other devices covered are thermal switches, liquid-level switches, static time-delay and sequencing devices, power changeover switches and annunciator panels. (64 pp) United Control Corp., Seattle, Wash.

Fasteners 955

For design engineers, a 16 page condensed catalog contains basic engineering data and specs on hexagon nuts, standards sizes ¼" to 3"; "Conelok", "Huglock" and "Marsden" locknuts sizes ¼" to 1-½"; Specials 7/16" to 4¼"; Weldnuts #10 to ⅝"; 12 Pointer nuts sizes ¼" to ⅝"; and 16 types of AN (air force-navy aeronautical) Nuts. National Machine Products Co., Utica, Mich.

AC Power Source 965

From a nominally fixed frequency input, an electronic source of ac power with rigidly defined characteristics provides a variable frequency output from the subsonic to the ultrasonic. Output frequency is stabilized to better than one part in one hundred million. Behlman Engineering, Burbank, Calif.

Time Division Switching 996

A resonant transfer technique for generating or detecting pulses in time division solid state switching is discussed. Included is a comparison of time division switching with space division and electromechanical switching and a comprehensive explanation of the function, operation and maintenance of time division switching. North Electric Co., Galion, Ohio.

Synchro Transmitters 680

Low and high pressure synchro transmitters and matching repeaters are described in two bulletins. Designed for applications requiring remote read-out with high accuracy, the units combined in a system attain an overall accuracy of ±1.0%. Servonic Instruments, Inc., Costa Mesa, Calif.

Panel Instruments 669

Miniature and full size electrical indicating panel instruments vary from ½" to 4½" in dia. Internal core magnets are self-shielding, thus eliminating the external magnetic field found in other designs. Models listed in catalog contain external zero adjusters. Instruments available: dc and ac microammeters, dc and ac milliammeters, ammeters, and dc and ac voltmeters. (24 pp) DeJur-Amsco Corp., Long Island City, N. Y.

Miniature Relays 671

Meeting the requirements of MIL-R-6106, —5757D and —25018, hermetically sealed miniature rotary-type relays are said to be the smallest 4 PDT, 10 amp units currently available. Glass-coated cylindrical contact actuators attach to the rotary armature to assure square mating of contact surfaces. Catalog includes mounting styles. (4 pp) Union Switch & Signal, Pittsburgh, Pa.

Mylar Capacitors 991

Miniature, hermetically sealed, metalized mylar capacitors for applications in transistor circuitry or printed circuits are described. Includes three series of mylar wrap epoxy end seal types and two series of mylar units in ceramic tubes; all in 200, 400 and 600 VDCW ranges. Potter Co., No. Chicago, Ill.

Shaft Encoder Translation 657

Technical brochure on shaft encoder translation describes in detail the operation of two basic models of shaft encoder translation equipment. Logical block diagrams and timing diagrams are included. (8 pp). Harvey-Wells Electronics, Inc., Natick, Mass.

Hi-Temp Capacitors 964

Containing complete physical and electrical characteristics of high temperature metallized paper capacitors, a catalog describes types which are now capable of operation to +125°C without voltage derating. Temperature characteristics curves and performance characteristics tables are included. Aerovox Corp., New Bedford, Mass.

Gas Chromatograph 688

Thermal conductivity filament type detection system of a chromatograph makes the instrument extremely valuable for trace analyses, even with very small samples. It has a fast response, full-flow cell geometry and a sensitivity 10 to 20 times greater than most filament-type detectors. (14 pp) Beckman Instruments, Inc., Fullerton, Calif.

Limit Monitor 693

Continuously monitoring millivolt outputs from thermocouples and other low level sensors, a solid state alarm indicates out-of-limit conditions by brightly lighting an incandescent lamp and sounding an audible alarm. Device operates remote indicators and other devices and will not trigger on random noise. It has a 10 year warranty. (4 pp) San Diego Scientific Corp., San Diego, Calif.

Thyratrons 690

How thyratrons differ from high vacuum tubes and how to interpret thyratron ratings are two of the many topics covered in two bulletins. Entitled "Thyratrons Are Different" and "The Care and Control of Thyratrons," they also discuss ionization and deionization, temperature effects, installation precautions, and ac and dc control. One section on applications describes a remote controlled switch, a welding timer, a motor control and a power inverter. (8 pp) CBS Electronics, Danvers, Mass.

Capacitor Reliability 689

"Capacitor Engineering Data Useful in Designing High Reliability Circuits," contains previously unpublished reliability test data accumulated on over 100,000 capacitors since 1930. The publication examines such parameters as voltage, temperature, frequency and insulating materials. It discloses how life, capacitance and leakage current are affected over extended temperature ranges. Dissipation factors are compared dating from time of linen paper to today's Teflon film dielectrics. (24 pp) John E. Fast & Co., Chicago, Ill.

Electronic Hardware 678

Catalog permits ordering from one source all hardware for aircraft, missiles, and electronic apparatus. In its pages are specs for screws and bolts, rivets, nuts, washers, pins, and all types of standard and "hard-to-find" fasteners. Illustrations show popular rivet head styles and standard head markings. Alter Bolt Co., Philadelphia, Pa.

Aerospace Fasteners 694

Selection guide covers materials, fabrication and quality control of critical high strength and high temperature fasteners for aircraft, missile, spacecraft and military electronics applications. Separate sections discuss heading practice, heat treatment, grinding, thread rolling and plating. Each relates specific techniques to beneficial properties in the bolting. Included is a rapid identification review of 120 aerospace bolts such as tension and shear bolts, engine bolting, titanium and specialty fasteners. (24 pp) Standard Pressed Steel Co., Jenkintown, Pa.

Precision Potentiometers 954

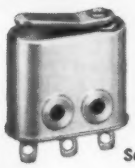
Ranging from 1 7/16 to 3 inches in dia, both servo ball-bearing and bushing sleeve-bearing potentiometers contain stainless steel housing clamps, a diallyl pthalate body, and solid-brass, gold-plated terminals, each welded to a single turn of wire. The 1 7/16 dia series is rated at 3 watts at 40 deg C derating to 0 at 105 deg C. Catalog lists standard availability values. (4 pp) Duncan Electronics, Santa Ana, Calif.

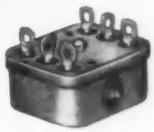
Reliability
IN OPERATING ENVIRONMENT WITH
HAYDON Switch INCORPORATED
SEALED SWITCHES

High temperature
Cryogenics
Corrosive media
Salt spray
Humidity
Oils
Gases
Oxygen
Icing
High Altitude
Explosion
Immersion
Dry circuit
Sand & Dust
Fungus

Standard Hermetically Sealed Switches, SPDT & DPDT

Series 6107


Series 61392

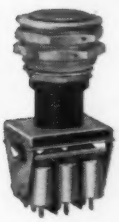

Series 8102

Series 61393 Hi Temp

Bonded Silastic seal or metal wobble diaphragm. Housings evacuated and filled with inert gas. Temperature in various ranges from −300°F. to +700° F. Operating force 9-64 oz.

Series 7102

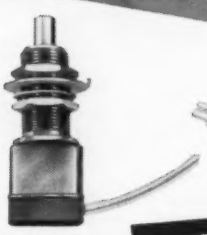
1-4 pole Pushbutton and Toggle Sealed Assemblies

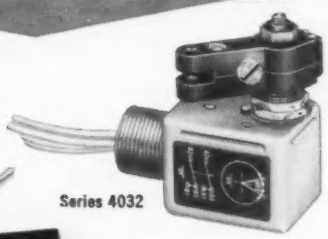

Series 61512

Series 6125

Series 6178

Sealed Plunger and Rotary limit Switches for Landing Gear and similar uses


Series 61358


Series 4032

Miniature and Subminiature sealed switches designed and qualified for AIRCRAFT, MISSILE, NUCLEAR and INDUSTRIAL HAZARDOUS DUTY LOCATIONS.

Write TODAY for NEW General Catalog.

HAYDON Switch INCORPORATED PLaza 6-7441
WATERBURY 20, CONNECTICUT

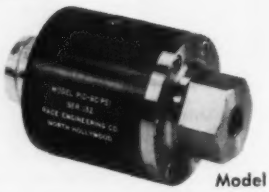
CIRCLE NO. 71 ON INQUIRY CARD

PACE AC TRANSDUCERS

Environment-proof PACE magnetic reluctance transducers assure Shock and Overload resistance. A pressure actuated diaphragm is the only moving part. High Output. ½% full scale accuracy. All Stainless exposure.

ABSOLUTE, GAGE AND DIFFERENTIAL — RANGES FROM 0.1 TO 10,000 PSI

Gage, Differential and Absolute instruments for low and medium pressure measurements of laboratory accuracy. Ranges of ±0.1 to ±1,000 psi. Accepts corrosive fluids, both sides.

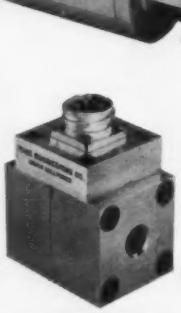


Model P1

Accepts gummy, dirty and corrosive fluids. Easily disassembled for field cleaning. Gage and Absolute instruments with ranges from 200 to 10,000 psi.

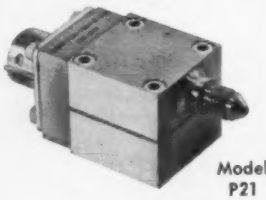
Model P2

Low pressure measurements at line pressures up to 5,000 psi. Ranges: ±0.1 to ±2,500 psid. Accepts corrosive fluids, both sides.



Model P3D

Miniaturized for missile and aircraft applications. Ranges of ±1 to ±1,000 psi — Gage, Differential and Absolute. Accepts corrosive fluids, both sides. Weighs only 4½ ounces.



Model P21

PACE also builds Thermocouple Reference Junctions, Telemetering Systems and components.

PACE *engineering company*

13035 Saticoy Street North Hollywood, California

CIRCLE NO. 72 ON INQUIRY CARD

ADVERTISERS' INDEX

ADVERTISERS	PAGE
Ace Plastic Co.	62
Automatic Electric Co.	9
Barksdale Valves	4
Beckman Instruments, Inc. *Helipot Div.*	25
Bird, Richard H., & Co., Inc.	46
Bourns, Inc. *Trimpot Div.*	41
Bristol Co., The	32
Clifton Precision Products Co., Inc.	cover 4
Consolidated Controls Corp.	67
Constantine Engineering Laboratories Co.	54
Controls Co. of America *Control Switch Div.*	12
Daven Company, The	cover 3
Daystrom, Inc. *Potentiometer Div.*	43
Dee Electric Co.	75
Dialight Corp.	22
Eastern Air Devices, Inc.	27
Edcliff Instruments *Con-Elco Div.*	63
Electric Regulator Corp.	76
Electro Products Laboratories	69
Electrofilm, Inc.	29
Electro-Mec Laboratory, Inc.	62
Elgin Micronics *Div. of Elgin National Watch Co.*	5
Ellis & Watts Products, Inc.	10
Engelhard Industries, Inc.	1
Fae Instrument Corp.	37
General Motors Corp. *New Departure Div.*	cover 2
Giannini Controls Corp.	58
Graphic Systems	56
Haveg Industries, Inc. *Taunton Div. (Havelex)*	72
Haydon Switch, Inc.	77
Heim Co., The	8
Heineman Electric Co.	2
Heinze Electric Co.	63
Houston Instrument Corp.	42
Howard Industries	69
Howell Instruments, Inc.	66
Industrial Timer Corp.	23
Julie Research Laboratories	31

ADVERTISERS' INDEX

ADVERTISERS	PAGE
KEARFOTT DIVISION *General Precision, Inc.*	53, 55, 57, 59
KOLLMORGEN CORP. *Inland Motor Corp. of Va.*	34
LEECRAFT MANUFACTURING CO.	72
METALS & CONTROLS CORP. *Div. of Texas Instruments Co.*	40
MUIRHEAD & CO., LTD.	80
NATIONAL PNEUMATIC CO., INC. *Holtzer-Cabot Div.*	60
NEWARK ELECTRONICS CORP.	30
PACE CONTROLS CORP.	68
PACE ENGINEERING CO.	78
PLASTIC CAPACITORS, INC.	65
POTTER & BRUMFIELD *Div. of American Machine & Foundry Co.*	21
REEVES INSTRUMENT CORP.	7
REVCO, INC.	63
SECON METALS CORP.	75
SEL-REX CORP.	65
SERVO-TEK PRODUCTS CO., INC.	39
SIERRA ENGINEERING CO.	56
SIGMUND COHN CORP.	30
SOLID STATE PRODUCTS, INC.	44
SOUTHWEST PRODUCTS CO.	20
STACKPOLE CARBON CO. *Ceramagnet Div.*	35
STAEDTLER, J. S., INC.	71
STREETER-AMET CO.	62
SUPERIOR MANUFACTURING & INSTRUMENT CORP.	26
TECHNICAL WIRE PRODUCTS, INC.	33
TECHNOLOGY INSTRUMENT CORP. OF ACTON	58
TEN BOSCH, M., INC.	18
UNITED AIRCRAFT CORP. *Norden Div. – Ketay Dept.*	11
VAP-AIR AERONAUTICAL *Div. of Vapor Heating Corp.*	13
VEEDER-ROOT, INC.	61
VERNISTAT DIV. *Perkin-Elmer Corp.*	6
VICTORY ENGINEERING CORP.	38
WAKEFIELD ENGINEERING, INC.	79
WEBBER MANUFACTURING CO., INC.	19
WILEY, JOHN & SONS, INC.	64

peas
in a pod . . .

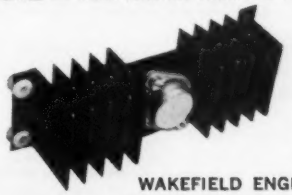
yet . . . one
semiconductor
will

LAST LONGER at HIGHER POWER!

Any semiconductor that is mounted on a DELTA-T Cooler will last many times longer, and/or at higher power levels, thereby achieving maximum reliability and customer acceptance of equipment design. By utilizing optimized design concepts and automated high-speed production techniques DELTA-T coolers offer maximum cooling efficiency at low cost — a cost far less than a burned-out semiconductor — and a burned-up customer.

DELTA-T semiconductor Coolers offer a broad line from which to choose, both copper fabricated and extruded aluminum units, in natural convection and forced convection models and complete cooling packages. Among these is a proven design that will fully and reliably satisfy YOUR requirements!

Write for Technical Bulletins describing DELTA-T Cooling units and modular, low cost, high efficiency complete cooling packages. Also available, new "Semiconductor Cooling Handbook", devoid of advertising, filled with engineering facts about proper cooling, which you will want to know. Application data sheets on special units — from rectifier stacks to diodes, also available.



Delta T
SEMICONDUCTOR
COOLERS

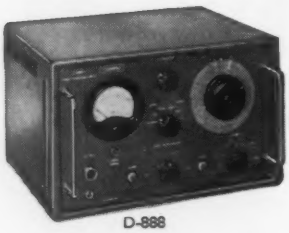
WAKEFIELD ENGINEERING INC., Wakefield, Mass.

CIRCLE NO. 73 ON INQUIRY CARD

WAVEFORM ANALYSERS

D-669

with a range of 1c/s-650kc/s



D-888

Models are available for automatic, semi-automatic or manual operation. Although designed primarily for vibration and noise measurements they are equally suitable for the analyses of most complex electrical waveforms.

K-100-A

Features: Most models give a choice of several bandwidth tuning conditions; constant percentage bandwidth; high frequency accuracy; wide amplitude range.

WRITE FOR PUBLICATIONS 100,101,105,138.

MUIRHEAD

Precision Electrical Instruments

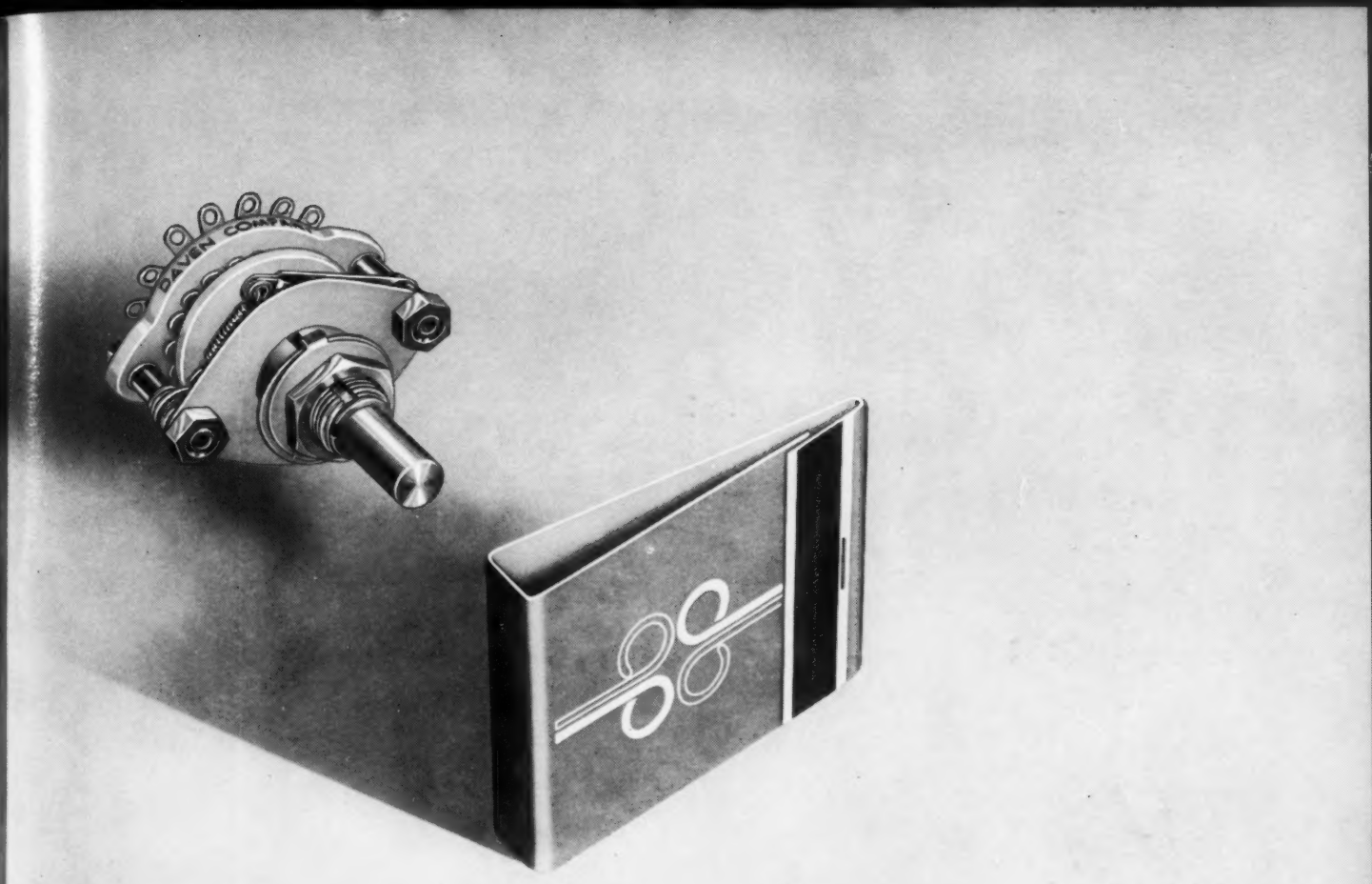
MUIRHEAD INSTRUMENTS INC., 441 Lexington Avenue, New York, 17, N.Y., U.S.A.
Telephone: Murray Hill 2-8131
MUIRHEAD INSTRUMENTS LIMITED, Stratford, Ontario, Canada
Telephone: 271-3880
MUIRHEAD & CO. LIMITED, Beckenham, Kent, England
Telephone: Beckenham 4888

510/3

CIRCLE NO. 74 ON INQUIRY CARD

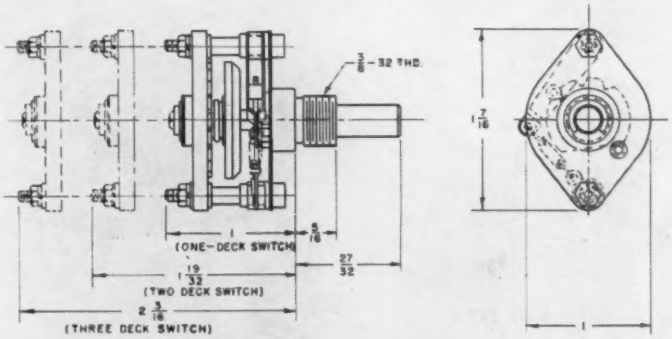
ADVERTISING PRODUCT INDEX

Product	Page
Amplifiers, servo	18
Analysers, waveform	80
Bearings, ball, linear motion	Cov. 2
Bearings, jewel	46
Bearings, spherical	8, 20, 67
Books, engineering	73
Brakes	37
Chains and sprockets	56
Choppers, dc to ac	32
Circuit breakers, miniature	2
Clutches	37
Clutches & brakes, size 5	Cov. 4
Contacts, dry circuit	33
Contacts, precious metal	1
Control, temperature	13
Converter, analog-digital	11
Cooling equipment	10
Counters, digital readout	61
Counters, Navigational	57
Dashpot, air damping	76
Digital control	78
Display boards	56
Drives, packaged precision	62
Encoder, magnetic	11
Environmental test chambers	19
Ferrites, recording head	55
Generator, tachometer	39
Gyros, miniature integrating	7
Heat sink mounts, semiconductor	79
Heating elements	29
Insulating materials	72
Lights, Pilot	22
Magnetic Amplifier Controls	13
Magnets, permanent	35
Metals, thermal	1
Meters, millivolt	66
Meters, time	23
Motors	27, 58, 60, 78
Motors, dc torque	34
Motors, universal	69
Parts, precision	62
Pencils, drafting	71
Pickups, magnetic	69
Plastic extrusions	62
Plating, precious metal	65
Potentiometers, ac	6
Potentiometers, precision	41
Potentiometers, trimming	25, 63
Potentiometers, zero backlash	43
Recorder, XY	42
Relays, germanium-alloy	53
Relays, power	21
Resolvers	59
Servo packages	26
Sockets, lamp	72
Solder pots	75
Switches	4, 12, 77
Switches, miniature cermaic	Cov. 3
Switches, semiconductor	44
Synchros	59
Tachometer, generator	39
Temperature cabinets	63
Thermistors	38
Time indicators, elapsed	5
Timers	23
Transducers, pressure	68
Transducers, position	69
Transistors, germanium alloy	53
Transistors, switching	44
Varistors	38
Waveform analysers	80
Weighing equipment	62
Wire, platinum clad	1
Wire, precious metal	30, 75
Yokes, deflection	54



DID YOU SAY | small? |

Occupying less than 1½ square inches of panel space, this Miniature Ceramic Switch nevertheless contains as many as **18 positions on a single wafer.** And it's rugged! Solid silver alloy contacts, rotors, and slip rings provide low and uniform contact resistance. Ceramic parts are silicone impregnated to function under extreme humidity. Sturdy solder terminals are supplied for wiring. This miniature switch meets and exceeds the electrical and environmental requirements of Mil-Spec S-3786. Flashover voltage at 60 cycles is 1000 volts peak . . . current carrying capacity is 2 amperes. For guided missiles, airborne radar equipment, portable and mobile ground equipment . . . for any application that requires an extremely small and rugged switch, specify Daven's Series M Miniature Ceramic Switches. These units can be "ganged" with up to 8 decks with slight mechanical modifications. 2 or 3 poles per deck may also be obtained as standard. Prototypes can be delivered within 2 weeks.



Write for complete information.

THE DAVEN CO.

526 West Mt. Pleasant Ave.
Route 10, Livingston, N. J.

TODAY, MORE THAN EVER, THE DAVEN (D) STANDS FOR DEPENDABILITY!

CIRCLE NO. 76 ON INQUIRY CARD

NEW

FROM CLIFTON PRECISION

SIZE 5 FREE CLUTCHES

SIZE 5 BRAKES

SIZE 5 BRAKE-CLUTCHES

- **GUARANTEED "NO-CREEP" DESIGN** (pat. pend.)
- **HIGHEST TORQUE PER WATT**
- **NO LOSS OF TORQUE DURING LIFE** (torque tends to increase)
- **NO TORQUE VARIATION WITH TEMP.**
- **OFF-SHELF DELIVERY**

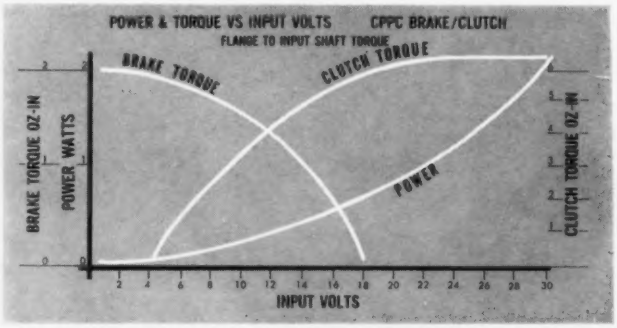
Well known as the quality manufacturer of highest accuracy and reliability synchros and rotary components, CPPC has now added to its line a series of optimum performance free clutches, brake-clutches and brakes.

These clutches were designed and fabricated for use in our Systems Division's Analog Navigation Computers as a suitable clutch could not be procured for sustained in-flight operation. They are designed to MIL-S-20708 and meet requirements of MIL-E-5400 and MIL-T-5422.

Write or call today for full information on these rugged size 5 components.

SPECIFICATIONS

Weight	0.97 Ounces
Minimum Engagement Voltage	6 Volts D.C.
Power Consumption	1.6 Watts at 28 Volts
Response Time at 28 Volts D.C.	2.8 Milliseconds
Inductance	0.33 Henries
Torque at 28 Volts D.C. Excitation	
Clutch	
Engaged (Minimum)	6.0 Ounce Inches
Disengaged (Maximum)	0.05 Ounce Inches
Brake	
Brake Torque (Minimum)	2.0 Ounce Inches
Polar Moment of Inertia	
Engaged	2.5 gm-cm²
Disengaged	1.6 gm-cm²
Backlash—Engaged	0 Minutes of Arc
Temperature Rise at 25° C	30° C



CLIFTON PRECISION PRODUCTS CO., INC.

Sales Department: 5050 State Rd., Drexel Hill, Pennsylvania
MAdison 2-1000, TWX LNSDWN, PA. 1122(U)—or our Representatives

cppc SYSTEMS DIVISION

CIRCLE NO. 75 ON INQUIRY CARD